# SILICON CHIP

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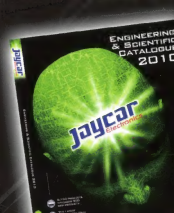


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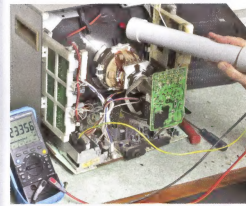

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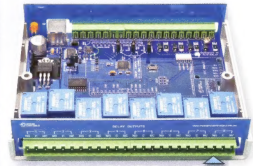

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# Publisher's Letter

## The Federal Government's insulation scheme is a tragedy

Back when the Federal Government's roof insulation scheme was first mooted I had some misgivings about whether taxpayer funds should be spent in this way but I let it pass. After all, I have similar misgivings whenever any government announces any scheme to "fix" a problem, especially when it involves direct subsidies to particular companies or to selected parts of the community.

Having said that, I don't think anyone could have imagined how bad the roofing insulation scheme would turn out to be. Last year I saw the press releases put out by NECA (National Electrical & Communications Association) and other relevant bodies, drawing attention to the safety risks but again, I did not conceive how crazy it would become. For example, I did not think that anyone would be silly enough to use aluminium foil insulation laid over ceiling joists and inevitably, over electrical wiring. Nor did I dream that such foil insulation would be installed using staple guns – the risk of shock and electrocution just beggars belief!

But it got worse – much worse! We now know about the fire risk. At the time of writing, there have been more than 100 house fires where the installation of insulation is suspected to be the main cause. However, while halogen light fittings and their transformers have often been implicated, that is not the whole story. In fact, it could be that electrical wiring which originally was quite safe is now rendered dangerous because it can now run much hotter. People do not realise that the Australian wiring standards (AS:NZS 3000) set the amount of current that can pass through power circuits on the basis that the wiring is sitting in free-air, ie, well-ventilated.

Furthermore, much of this roofing insulation has been installed in homes which are quite old. Often these houses have sub-standard wiring where the cabling uses cotton-covered rubber or vulcanised rubber insulation. This stuff is a fire hazard anyway but will be more so if it has been disturbed by people moving about in the roof space, installing insulation! And now that such old wiring is covered by insulation, it is more likely to fail, even if it hasn't been disturbed.

Even if none of these problems were in existence, it seems silly to install any form of insulation in the roof space so that much of the electrical wiring is concealed. It means that it becomes difficult to do any repairs in future.

So what to do now? The Federal Government has now announced that it will remove aluminium foil insulation from all homes or failing that, it will have RCD safety switches installed to combat the risk of electrocution. Well, yet again, the Government simply doesn't realise the full extent of the problem. NECA has just released a press release saying that safety switches are not the solution. Indeed, they are correct although they haven't said why.

In fact, RCDs can only protect the house wiring which is downside of the meter box. They cannot protect against the electrocution risk from the main 230VAC feed cable coming in from the street. It is also safe to say that you would need a qualified electrician to inspect the roof space and identify the main feed cable – that is just not going to happen. Furthermore, RCDs cannot be used to protect wiring which feeds hot water systems so you potentially have a number of electrical circuits in the roof which cannot be protected. Even if they are installed, RCDs will not mitigate the risk of fire in sub-standard wiring. With that in mind, there is no solution other than removing all foil insulation installed under the Government's scheme.

But that will not prevent the occurrence of fires because insulation batts have been laid over old wiring, halogen lamps or their transformers. And nor can any number of roof inspections totally remove that risk. There will certainly be more fires – that is unavoidable. Ultimately, the legal fraternity will have a field day.

It seems to me that the Federal Government's insulation scheme will go down in history as one of the worst ever government initiatives since Federation.

**Leo Simpson**

# MAILBAG

Letters and emails should contain complete name, address and daytime phone number. Letters to the Editor are submitted on the condition that Silicon Chip Publications Pty Ltd may edit and has the right to reproduce in electronic form and communicate these letters. This also applies to submissions to "Ask SILICON CHIP" and "Circuit Notebook".

## Desalination is a waste of electricity

I have read a lot in SILICON CHIP about where the electrical power is to be generated to supply the desalination plants that governments believe we require. To me it seems just a waste of electricity. If you could see the amount of fresh water that goes past our place in the stormwater drain and straight into the bay to become salt water during an ordinary rain shower, you would be amazed.

A few years ago, we installed a rainwater tank to collect the water off the house and the garage. We need about 75mm of rain to fill the tank from empty. The tank size is 22,500 litres and is enough for two people in this area. We recently came out of the longest dry spell that anyone can remember, yet we did not run out of water.

In other words, we have not used any town water since we got this system up and running. It cost about $8000 to install and costs the following per year to operate:

(1) 3-5 micron sediment filter – $36.00
(2) 1 micron activated charcoal filter – $60.00
(3) 1 UV tube (for steriliser) – $150.00

The total is $246.00 plus the cost of electricity and maintenance which is not much. As you can see, we have top-quality water but it is not free.

I know that a lot of people on small allotments and in apartments etc would not be able to do this but there is a very large number who could. The trouble is that there is no incentive to put in such a system because we only save on the consumption part of our water rates.

**R. A. Groves,**
**Coloola Cove, Qld.**

## Increased wind power is more problematic

When I wrote to SILICON CHIP (Mailbag, January 2010) refuting the claim that wind farms could supply the entire power requirements of a desalination plant, I hoped to start discussion on the wider usefulness of wind energy. A contributor to Mailbag in the February 2010 issue, Kevin Shackleton, has responded by analysing the relevant AEMO data and providing some thought-provoking comments.

Kevin is correct in stating that the connection of several wind farms spread over a wide geographic region does result in some smoothing of the total output compared with that of any single wind farm. In saying that the summed output is more noisy, I was looking at it from the grid manager's perspective. The output might be smoother but if the variance is not much improved, as indeed Kevin found, the absolute amplitude of the power spikes is larger, consistent with the larger total installed capacity.

Under this circumstance, the larger the proportion of wind generation in the grid, the more difficult its management becomes, because only the faster-acting forms of generation can be used to track and compensate for it.

As Kevin alludes, if there is sufficient spare hydro generation available, then this might be used to compensate for the variations in wind output (Snowy Hydro and larger Hydro Tasmania stations are not included in the same "Non-Scheduled Generation" AEMO category as wind output). Hydro is used extensively to manage existing rapid changes in demand, so the extent of "spare" capacity available to balance wind generation variations is not easy to determine.

In this regard, I quote from the Australian Energy Regulator's "State Of The Energy Market 2009" (page 14): "As the cheapest and most mature renewable energy technology, wind generation is likely to grow significantly under the expanded RET. But wind generation depends on prevailing weather conditions, and its intermittent nature poses challenges for power system reliability and security. In addition, momentary fluctuations in wind output create issues for maintaining

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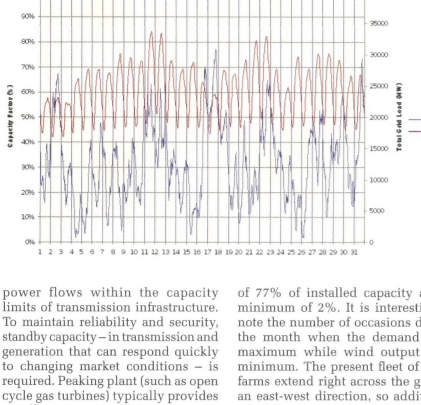
## Mailbag: continued




power flows within the capacity limits of transmission infrastructure. To maintain reliability and security, standby capacity – in transmission and generation that can respond quickly to changing market conditions – is required. Peaking plant (such as open cycle gas turbines) typically provides standby generation capacity".

Open cycle gas turbines (OCGTs) are then required to fill the bulk of the required balancing role. I think we can also presume from this quote that there is no "utility-scale" energy storage solution at present. The question that arises is: what amount of OCGT standby capacity is required?

I have looked at the variation over time in the total wind generation output. The installed total wind capacity, as Kevin has found, is at present a little over 1600MW. Above is a composite chart showing the variation in total wind generation (blue trace) during January 2010, together with the total grid demand (red trace). (Note that the righthand total demand scale is different to that used for the wind output. The latter is expressed as a percentage of total installed wind generation capacity.)

Apart from showing a somewhat smoother output than that from a single wind farm, the curve shows that the output swings between a peak of 77% of installed capacity and a minimum of 2%. It is interesting to note the number of occasions during the month when the demand is at maximum while wind output is at minimum. The present fleet of wind farms extend right across the grid in an east-west direction, so additional wind farms, being embedded in the same weather systems, will probably not add further smoothing and so the power spikes will grow with increased installed wind capacity.

This result for a single month has important consequences. There have been other times when the total output from wind generation right across the eastern Australian grid has been zero. Zero output, on even one occasion during the year, requires a 100% standby capacity of the installed wind farm capacity. The present requirement then is 1611MW of OCGT to back up the wind generation. Because the eastern Australian grid (comprising Queensland, NSW, Victoria, South Australia and Tasmania) is geographically the largest interconnected grid in the world, this result has consequences worldwide.

Kevin suggests that wind generation poses a "considerable challenge". It does indeed and this challenge has very significant financial consequences. These consequences are borne entirely by the hapless electricity consumer. Some years ago, Origin Energy published a submission to a Victorian government inquiry in which the company argued strongly for a strategy of introducing closed-cycle gas turbines (CCGTs) rather than the wind/OCGT hybrid. CCGTs are far more energy-efficient than both OCGTs and even more so than coal-fired plants.

Unlike wind/OCGT hybrids, CCGTs can fully take up the base load requirement presently met by coal-fired plant. Therefore the use of CCGTs would result in a very large net reduction in greenhouse gas emissions.

Another important consequence of taking the wind/OCGT route pointed out by Origin in the report is that the volatility introduced by wind (as shown by the chart) results in potentially very high spot prices (presently capped at $10,000 per megawatt-hour!) for electricity during those periods where the wind output is falling rapidly.

Wind farms attract a subsidy sufficient to cover the very high capital cost and the rapidly-varying output is compensated for by OCGT-supplied power provided at potentially very high spot prices. The consumer pays handsomely but for what? Are there companies owning both wind and gas generation assets? A quick check will show that the major gas companies do indeed have large investments in both wind farms and new-build OCGT plant.

In essence, depending on the rapidity of the changes in wind output at any time, the gas companies can bid, and be paid, potentially very high prices to provide the very power which is required to compensate for the vagaries of their own wind generation fleet.

The other very high-cost item, again a cost borne by the electricity consumer, is the requirement to provide augmented and new transmission line capacity to move large blocks of power around to deal with wind's intermittent and variable nature.

As Kevin said, a "considerable challenge". It is also an extremely expensive one but one that I suggest is entirely unnecessary and avoided by ignoring wind power altogether and instead choosing, as an interim, a

far more energy efficient alternative – natural gas powered closed-cycle gas turbine generation.

**Paul Miskelly,**
**Mittagong, NSW.**

References: (1) Australian Energy Regulator, State Of The Energy Market 2009 – see **http://www.accc.gov.au/content/index.phtml/itemId/904614**. (2) Origin Energy 2006, Driving Investment in Renewable Energy in Victoria. Options for a Victorian market-based measure. Submission by Origin Energy in response to the Issues Paper released by the Department of Infrastructure and Department of Sustainability and Environment, December 2005.

*Comment: as a result of proposed changes to the Federal Government's renewable energy target scheme, wind energy companies such as Pacific Hydro and AGL have nominated more than $6 billion worth of wind farms which could be revived. This amounts to some 2325 megawatts of wind power.*

*Just how these will be backed up is not known.*

## Comment on Serviceman's Log

In the Serviceman's Log for March 2010, there is a reference to a speaker transformer which had the high-voltage B+ connected to its laminations.

There was a speaker transformer made like this many years ago (could be 50) and I wonder if it was one of these or using a similar construction. The idea was to prevent breakdown to the core of the high-voltage B+ which was apparently a problem. As far as I can remember, they were first put out by Rola Loudspeakers and went under the trade name (I think) of Isocore.

These transformers came in a pressed, loaf-of-bread shaped aluminium container and the whole transformer, core and windings, were potted in a bitumen compound for sealing and safety purposes I had a Rola 12-inch type AX or UX loudspeaker type which I think had such a transformer.

**Brian Coulson,**
**Balcolyn, NSW.**

## Q1437 digital thermometer availability

I have an application for your Temperature Logger/Controller described in the January & February 2010 issues and have found a very real problem. My DSE Q1437 DMM looks identical to yours on the outside but it's quite different inside! The main IC is an ICL7135 and the other is some device that is hard to identify, as it's not clear what the main part number is.

Do you have any data on this version? For your information, the serial number of my meter is 02000321. Maybe DSE can advise when the change took place and you should publish this, to prevent folk from buying the wrong one!

**Barry Lennox,**
**Rangiora, NZ.**

*Comment: unfortunately, it seems possible that your version might be old stock. The sample Q1437 we obtained*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## CFLs still have poor reliability

This is a follow up to my letter entitled "Flashing CFLs Make Home Like A Disco" in the Mailbag pages of the September 2007 issue.

It's been about 2.5 years since we moved into our new house and I've been keeping track of the reliability of the installed light bulbs, comparing the different technologies. I did not record the hours used for each type but they are of typical home usage. The results are in the accompanying table.

**Light Bulb Reliability**

| Type | Quantity | Failures | % Failed | Notes |
|---|---|---|---|---|
| CFL | 22 | 7 | 32 | |
| 36W 4ft Fluoro | 6 | 0 | 0 | |
| 18W 2ft Fluoro | 11 | 2 | 18 | Both failures in bathrooms |
| 28W T5 4ft Fluoro | 6 | 0 | 0 | |
| Incandescent | 6 | 2 | 33 | Includes fridges |
| LED mr35 Downlight | 6 | 0 | 0 | |

From this small data sample, my initial conclusions are that CFLs are only marginally better than incandescent lamps for reliability. The CFLs that failed were well-known brands. What is interesting is that not one of the CFLs of dubious origin/brand from the local $2 shop have failed.

The most reliable fluoros were the 4ft ones, both the old type and the newer T5s. And the only 2ft ones to fail were both installed in bathrooms, if that has caused any difference in reliability. As expected, there have been no failures of the LED down-lights.

Two of the incandescent bulbs that failed were "bug bulbs" (yellow anti-insect types) and after a bit of searching for CFL replacements, I found 11W CFL "bug bulbs" at an electrical wholesaler for $8 each. However, they were BC socket types and I required ES (Edison Screw) so I ordered them, assuming that they would be about the same price only to be totally blown away by the $60 bill for four of them.

After being stung by that, I decided to do the maths and see how long it will take to recover the cost, compared to using the 75W incandescent "bug bulbs" at $2.75. It turns out that even at that price the CFLs should start saving money after about a year, if they are run for four hours per day. That would be well and good, however one of the CFL "bug bulbs" failed after one month and another after three.

So much for CFLs lasting longer than incandescents.

At that sort of failure rate and replacement cost it would be cheaper to burn one dollar bills to keep the insects away. That leads to another point: have you ever tried to claim warranty on a light bulb? The shops won't hear of it. A compact fluorescent is an electronic appliance, isn't it? So my conclusion is that the only type of economical light bulb to run is a reliable one.

**Ray Hudson,**
**Mareeba, Qld.**

*when preparing the article for publication has S/N 09000046 – much later than your version.*

*We also had another New Zealand reader advise that he was unable to obtain the Q1437 Digital Thermometer. However, it is still available for $99 (AUD) on-line at* ***http://www.dse.com.au/cgi-bin/dse.storefront/4b90941102e3192e2740c0a87e010683/Product/View/Q1437***

## Further argument on active crossover

Sometimes you need to admit that you are wrong. Your original reply to John Yelland (Mailbag, December 2009, page 9) contained errors. With your subsequent reply to Greg Mayman (Mailbag, February 2010, page 7) you have compounded your errors.

When you are combining the outputs of a high-pass and a low-pass filter, it is not correct to design for crossover at the -6dB points. When you combine two relative -3dB signals of equal phase then you will get a signal of 0dB relative. But when you combine two signals from an LP and a HP filter with the same crossover frequency, as you have defined it (that is, they are 6dB down at the crossover frequency) you will end up with a combined signal that is 3dB down.

So you will have a dip of about 3dB at the crossover frequency. Instead you should have designed the total filter for a -3dB point instead of a -6dB point. It is easy to do, so it is a puzzle as to why you did not this.

All you had to do was design the 2-pole low-pass filter stage for a -3dB point of $\sqrt{2}$ x the crossover frequency, or 1.4 times. And for the high-pass filter, a -3dB point of $1/\sqrt{2}$ of the crossover frequency.

In case people are thinking of just using one stage of the filter instead of the two, there would be a problem due to the phase shifts of the filters. A Butterworth 2-pole filter will have a -90° phase shift for a low-pass and a +90° phase shift for high-pass filter at the -3dB points. So if you add the outputs together for a single 2-pole filter, you will end up with a notch at what was the -3dB frequency.

But with the dual 2-pole filters that you have chosen you will have 180° phase shifts at the -6dB frequencies, so the added outputs will end up in phase at this -6dB frequency. The summing would have been correct.

**Bruce Withey,**
**Mylneford, Vic.**

*Comment: the reason why previous correspondents have been confused is that the Linkwitz-Riley crossover filter featured in the July 2009 issue was predicated on a corner frequency which is -6dB down rather than the conventional crossover filter cut-off of -3dB. Hence, when a Linkwitz-Riley HP and LP filter with the same cut-off frequency at -6dB are combined, the*

*overall frequency response is flat.*

*The specific design procedure advocated by Linkwitz & Riley in their original paper is to use the -6dB point. This is because, as we understand it, the on-axis response is up by 3dB compared to the overall response, due to constructive interference. If we used the cut-off frequency (ie, -3dB point) as the crossover frequency instead, it would result in a +3dB peak. Unfortunately, this was not explained in the June 2009 article.*

## CFLs can be long-lived

Using an indelible felt tip pen, I have a habit of writing the installation date on the bayonet of light bulbs. I recently replaced a compact fluorescent lamp which I installed on 14 December 1996. It was a Philips brand, made in Poland, model SL*25C N13950.

I recall it was expensive at the time of purchase but I feel confident it was worth the initial outlay.

**Andrew Mackinnon,**
**Main Ridge, Vic.**

## VU meter clarification

In the February 2010 issue, you answered a query from a reader about VU meters (Ask SILICON CHIP, page 98). You referred to the Altronics Q-0490 VU meter and indicated that it is a true AC meter with predefined attack and decay response.

I have used several of these meters in projects and can assure you that it is simply a DC milliammeter that will give a full-scale deflection with approximately 0.6mA, despite having a scale marked in VU. To use it as a VU meter, it is necessary to add a full-wave rectifier plus a filter network to approximately achieve the ballistics of a true VU meter.

As you suggest, this network needs to be fed from a low-impedance source with adequate signal handling capability and also have an attenuator so that the sensitivity of the meter can be adjusted to suit requirements.

**Neil McCrae,**
**East Hawthorn, Vic.**

## E-waste recycling is happening

I always find your Publisher's Letters to be of interest but the one in the in the March issue caught my attention and you may be interested in the following information.

I live in Baw Baw Shire in country Victoria, about 100km from Melbourne. Our shire operates a waste disposal scheme, run on their behalf by a private contractor, with a landfill tip at some distance from where I live but there is also a garbage transfer station not far away. Garbage, garden waste and general waste is accepted for a fee but paper, certain types of glass (not picture tubes) and metal, including refrigerators and washing machines, etc are regarded as recycling which is accepted without charge.

In the past, if I have had any old electronic waste to dispose of, I have had to pay for it to go as waste to the landfill. However, within the last year or so, they have commenced recycling electronic waste and it seems that this facility is also being established at other places.

I had a collection of old TV picture tubes and parts, computer monitors, old computers and an old microwave, etc which I wanted to dispose of. There was a large shed with the floor covered about 400mm deep with large quantities of old electronic equipment and I was able to leave all my trash there free of charge.

The question that was prominent in my mind was, "What would they do with all this stuff?" The cost of dismantling it would far outweigh the scrap value of any recovered materials and I could not see sufficient value in it to offset the cost of shipping it for processing in third world countries. Obviously I was wrong because the fact that they are actually doing something with it proves that it is viable.

**Harry Pfeifer,**
**Warragul South, Vic.**

## "Freeview-Approved" HDD recorders are crippled

With reference to the "Digital TV – Where To From Here" article in the


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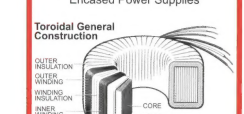


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## Mailbag: continued

March 2010 issue of SILICON CHIP, I must advise against the recommendation in the side-bar "Which Set To Buy?" concerning "Freeview Approved" sets.

Yes, "Freeview Approved" means the TV/set-top box will be able to decode MPEG-4 transmissions – if they ever come to fruition. What it also means is that, assuming the TV/set-top box has an inbuilt HDD (hard disk drive) recorder, you'll miss out on some of the best (in my opinion) features of a HDD recorder. Specifically you won't be able to instantly skip ads nor transfer shows recorded off-air to other devices.

HDD recorders typically have a "skip forward" button, which usually instantly skips forward 30 seconds. Adverts are usually 30 seconds long, so when you hit an ad break, you jab the button several times and you're instantly past the ads. If you've gone a little too far there's usually a "skip backward" button which skips back 10 seconds or so. So a few button jabs and no annoying ads.

"Freeview Approved" HDD sets have the skip forward/backward buttons but the minimum skip time allowed is 10 minutes (from recollection). Of course, you can still fast forward through the adverts but this is far clumsier.

Some HDD recorders have USB or network ports – both for playing media from the USB/network and for copying recorded shows to other devices. "Freeview Approved" sets do not allow off-air recordings to be copied off the original recorder. You can still copy media files onto the recorder from other devices and copy those same files off again but the device is prohibited from allowing recorded shows to be copied off the device.

I was in the market for a new HD set-top box with HDD recorder a few months ago and was on the verge of buying a "Freeview Approved" box. "More future-proof" I thought, as I knew that only "Freeview Approved" boxes would handle MPEG-4. But then I stumbled across an internet forum or two which revealed the horrible truth.

In some cases, there are similar "Freeview Approved" and non-approved sets from the same manufacturer. Careful reading of the manuals will reveal the differences but they certainly aren't pointed out.

In the case of the set-top box I brought, the skip forward/backward time is user settable and there are actually separate settings for off-air recordings and other media (eg, files on a USB drive, which can be played via the box). The Freeview model allows a minimum of a 5-second skip for "other media" but imposes a 10-minute minimum skip for "off-air". The non-Freeview model allows a minimum of five seconds for both.

The non-Freeview model also allows any file to be copied off the box, to USB or network, while the Freeview box only allows "other media" to be copied.

If there's a choice between perhaps a better picture sometime in the future, and being able to skip ads right now, I know which choice I'd make – and have. Perhaps if enough people refuse to buy "Freeview Approved" it will die and everyone will be able to benefit fully from HDD-recorded TV.

I've owned six consumer HDD video recorders over the last eight or nine years and all – from the first $3000 one to the cheap $40 web purchase – have had a usable skip function. None of them have been "Freeview Approved".

**Adam Webb,**
**Adelaide, SA.**

### Milliohm Adaptor was undersold

I enjoyed the article on the Milliohm Adaptor for DMMs in the February 2010 issue but feel you have undersold the benefits of the 4-terminal measurement system. Lead resistance can be measured and subtracted but contact resistance cannot.

As I write, I have in front of me a common 5W 0.1Ω rectangular white-bodied resistor. Measuring its resistance with an expensive multimeter on a 0–50Ω range with 5000-count resolution and hand-held probes, I got a result that wandered between 0.09Ω and 0.12Ω. When I changed to spring clips, I got between 0.07Ω and 0.11Ω.

### Home insulation debacle raises safety questions

It is interesting to note that most of the home insulation installer fatalities due to electrocution happened in Queensland, the state with the most restrictive and closed shop system for electrical contractor licensing. Why were safety switches not tripped when there was a current path between Active and ground (ie, through someone's body)?

Why do transformers used in ceiling lighting have no thermal cutout and are therefore a fire hazard? One of the electricians interviewed on TV specifically mentioned that he had actually seen "melted transformers". Surely that should not happen or are our electrical safety people not concerned with the design of these things?

A good look at electrical standards would be more useful than simply calling for Peter Garrett to resign.

**Horst Leykam,**
**Dee Why, NSW.**

*Comment: it's possible that most of the fires may have been started by the halogen lamps rather than the transformers. As far as we know, many halogen lamp transformers do have thermal cutouts.*

*Either way, even the most basic instructions for insulation installers should have included a strict warning and prohibition against laying insulation of any kind over halogen lamps and their transformers.*

*Halogen transformers certainly do get very hot, even when running in clear air. They have a very poor magnetic circuit and they can dissipate 20W or more, meaning that each 50W halogen lamp actually pulls more than 70W. If you point an IR camera at the ceiling, it is very easy to see the hotspot outline of the transformers.*

*As we have commented in the past, 12V halogens for domestic lighting are a bad idea because they are so inefficient. In fact, it would have been better if the government had moved to ban those before banning 240V incandescent lamps. In fact, as we understand it, they will be banned in a few years' time.*

*As far as safety switches are concerned, they would only protect the power circuits in most homes and since a large portion of the wiring in the roof space of homes is associated with lighting circuits, it would not be protected. We will have to await coroners' reports to learn the precise causes of the fatalities.*

*It may be many years before all the ramifications of this scheme are played out.*

When I removed and reapplied the clips, I got between 0.12Ω and 0.14Ω.

Then I used my 4-lead Milliohm Adaptor; it said 99.94mΩ, with just a flicker in the last digit. That is with hand-held probes (no spring clips). When I held the probes on the very ends of the resistor leads, I got 100.63mΩ.

When I removed and replaced the probes, that result was repeatable to within ±3 in the last digit. When I placed the probes on the leads next to where they enter the body of the resistor, I got 99.9Ω, again repeatable to within ±3 in the last digit.

I have been using my adaptor for some four years and it has been a joy to use, with steady and reproducible readings. I recommend the method to anyone who has to make even occasional low-resistance measurements.

To simplify the process of connecting the four leads, I made up a pair of double probes. Each consists of a strip of Veroboard, two conducting strips wide (0.2-inch) and about 1.5 inches long. I soldered a piece of heavy copper wire (1.8mm diameter) along each of the Veroboard strips, effectively making the strips stand proud, and tinned them for their whole length.

A lightweight twin flex connects the two probes to the adaptor – one lead to the force terminals and the other to the sense terminals.

In use, I press the double probe on to the lead with a finger on the back of the Veroboard. I can often hold both double probes in place with one hand. One tip: if measuring the resistance of a short length of wire, the resistance measured will be that between the inner two of the four probes, irrespective of whether they are force or sense, or one of each.


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## Mailbag: continued

### Solar storage only a concept

In Mailbag (March 2010, page 9) you cite **www.beyondzeroemissions.org** as a source of information on solar storage. Unfortunately, comparing other sources of information on the internet, like Wikipedia entries, to that organisation's media releases suggests it is a source of exaggeration and disinformation.

For example, the one titled "Solar Power All Through The Night" which says "While solar electricity was once limited to when the sun was shining, solar thermal energy can now operate 24 hours a day, even at night, with an ingenious and cheap storage method utilising molten salt. There are plants in Spain operating with energy storage right now, providing electricity all night long".

The facts, as other sources state them to be, are as follows:
(1) the plants in operation in Spain use water for energy storage;
(2) it provides a maximum of one hour of storage;
(3) molten salt is not in use at any plant in operation and is quite expensive.

I would like those other sources to be wrong and Michael Wright from Beyond Zero Emissions to be right. Is he?

**Gordon Drennan,**
**Burton, SA.**

My adaptor is based on the circuit you published in Circuit Notebook in July 2000 but uses an inverter (adapted from the 3V-to-9V Converter item in Circuit Notebook for March 2004) to provide the op amp and Mosfet drive. It runs off a single 1.5V "D" cell, uses a force current of 1A or 0.1A and has a LED which warns if the op amp is approaching saturation (and consequent loss of regulation of the force current).

**Mike Emery,**
**Fern Tree, Tas.**

### Mullard radio had WA coverage

Just in case you have not yet had a flood of correspondence defending WA, I would like to ease Rodney Champness' mind regarding the Mullard radio featured in the February 2010 issue. The photo on page 90 clearly shows 6WF, 6WN and the Perth commercial AM stations on the dial scale.

Even just counting the six divisions on the scale would have indicated that all six states were represented.

**Rudolf Heitz,**
**via email.**

### Mac review like side-show alley

SILICON CHIP fills an important role in the popular technical press and, with the demise of so many similar overseas magazines, one can now say it does so globally. Over the years, SILICON CHIP has defined its own special style of technical writing which for the most part is balanced and logical and based on scientific reason.

I like reading SILICON CHIP and these comments apply equally to construction articles and product reviews.

Then occasionally, for no good reason, an article of the type written by Kevin Poulter in the March 2010 publication appears between the covers. Apple has for a long time made interesting pieces of equipment. More than once Steve Jobs has been responsible for leadership that has resulted in stunning products.

However, everything that Apple and other manufacturers make can be assessed logically, impartially and with substance. If this is done properly, readers are always that bit wiser.

But the style of expression in the abovementioned article would be more appropriate outside a sideshow alley by a spruiker than in SILICON CHIP. Furthermore, Kevin Poulter does no credit to the product when it is reviewed in this way. Please keep up the otherwise high standard of technical writing.

**Kenneth E Moxham,**
**Urrbrae, SA.**

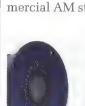
*Kevin Poulter comments: when Apple went to OSX, I was considerably disappointed – they introduced a new learning curve and took some old favourites away – trying to appeal to PC users at the expense of loyal Mac followers. There were scores of examples – even the annoying "are you sure you want to shut down?" It seemed to have worked though, as many PC users have adopted Mac.*

*So after using various Mac OS's in parallel with a PC at work, no computer got me enthusiastic.*

*It was with considerable reservation that I decided to purchase the latest Mac. It's also important to know I paid the $1200 to purchase one – Apple didn't even know I was reviewing the MacBook. What could be less biassed than that?*

### Mac review wasted pages

I really like your magazine but am annoyed that you wasted five pages on a computer review. Not only that but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it was rife with false and misleading information:
(1) Macs do have viruses, adware and spyware and OSX has had numerous security vulnerabilities over the years, often critical ones. It takes longer for Apple to patch them than it does for an anti-virus company to release a new definition. People really need the extra protection of an anti-virus solution and as more people use Macs, malicious coders will have more incentive to target them more frequently too.
(2) I've worked with PC/Mac/Linux in desktop and server environments for nine years now. While the price of Macs has come down significantly, you can still buy an equally-specced PC for half the price of a Mac.

On another tangent, I've found the Publishers Letter purposefully taking an extreme view, trying to incite opposition. He often comes across as old-fashioned, with views that we can do anything to this planet without consequence. These views and actions have historically left us in the younger generation a lot of problems to address.

**Gavin Kalms,**
**Upper Coomera, Qld.**

## Mac review omitted important points

I look to SILICON CHIP for articles and information on subjects not well (if at all) covered by other press. I was disappointed to see the glowing review of a Mac computer in the March 2010 issue. Such an article is "dime a dozen" in mainstream press and indeed it omitted important points that may be useful for readers of SILICON CHIP.

For example, it's still uncommon for electronics vendors to provide Mac versions of their software. I use a Mac at home and at work, so I'm speaking from experience.

**Ben Low,**
**Wollongong, NSW.**

*Kevin Poulter comments:*
*(1) I recommend the use of anti-virus software and said so in the article. My Mac or files have never been disabled by a virus.*
*(2) Macs are comparable in price, as you can open the box and operate a wide range of software that's already loaded, including word-processing that is compatible with PCs, video editing, organise and download photographs, edit and compose music and more. The ability to make PDFs from almost any file is used almost daily. But all this is not as important as the ease of use and features.*

*There may be some industrial software only for PC, however I am not aware of any popular software that is not available. This is an old argument against Macs. In fact, the Mac has some outstanding software that's only available in its platform, such as "Pages" (a brilliant document layout application) and "Keynote" which is arguably better than Powerpoint.*

*A Mac user can save documents in Word format, never needing to buy the software – or can purchase the Microsoft suite to have total compatability with PCs. You can even run Windows on a Mac, though few would need to.*

*I used a PC daily for two years at work and took a Mac each day to use whenever possible. I agreed in the article some prefer or even need to use PCs but a Mac is worth considering and the difference to my work-flow since acquiring this 2010 Mac this year has been amazing.*

*I use four Macs and until the latest one, would not have tried to point out the advantages – it's that good.*

## E-waste farce

I read your latest Publisher's Letter on e-waste in the March 2010 issue and agree with several of your points.

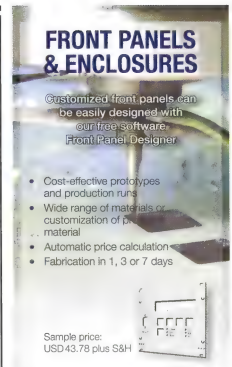
Local councils, here in NZ at least, are strange beasts. They do not let the facts get in the way of "good" policy or "vision" and will happily squander money on it.

In NZ, we have an annual e-waste collection (eDay). It collects about 1000 tonnes nationally and about 60-70 tonnes in the Auckland region. The landfill that serves the Auckland region accepts 750,000 tonnes of total waste annually. Which ever way you do the sums, eDay is irrelevant in the margin of error.

To top it off, the eDay collection was announced and happened after the council's annual street clean-up!

What this all means is that regulation and funding is required from a national level. Just as glass bottles used to have a deposit, so must e-waste.

**Allen Reynolds,**
**North Shore City, NZ.** SC

*The world of 3D television, photography, movies, scientific tools and prints is finally here. After primitive attempts at 3D for many, many years, top-quality three-dimensional imaging is now available for all.*

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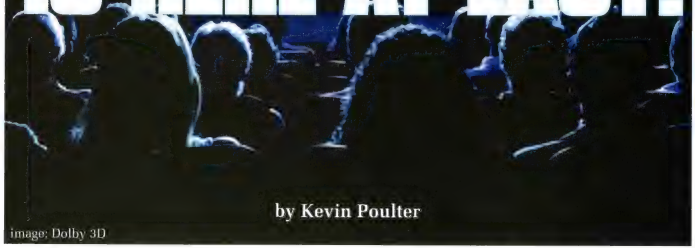


by Kevin Poulter

image: Dolby 3D

**While 3D still has some shortcomings**, the technology and financial incentives are now in place to achieve a brilliant outcome. Most new 3D systems use specialised cameras with two lenses plus two films or image sensors. Viewing is via special glasses, typically with LCD shutters.

3D has been coming for a long time, nearly 200 years in fact. The Stereoscope viewer was the first true 3D device, magically creating depth from two images glued onto a card, slightly out of register with each other. The images were drawings, prints or photographs.

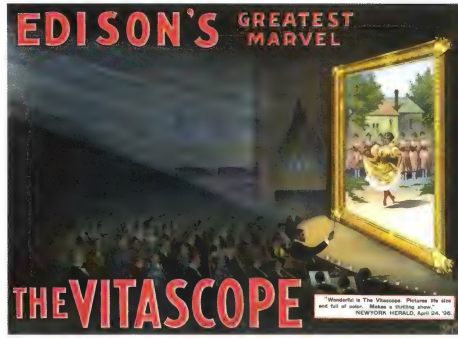
Stereopsis was first described by Charles Wheatstone in 1838. To display his 3D pictures separately to the two eyes, Wheatstone invented the Stereoscope.

It works by having two images drawn or captured from slightly different perspectives, emulating the distance between the viewer's eyes. By making closer objects relatively further apart than distant objects, it fools the brain into believing that the image being viewed is actually 3-dimensional.

There are other cues which can enhance the illusion. For example, when the viewer's eyes are focused on a foreground subject, background objects are out of focus and appear blurred. By purposely blurring the background, an image can re-create this effect.

Another cue is occlusion of one object by another – the manner in which an object closer to the viewer masks (or occludes) an object further away.

Other cues include the subtended visual angle of an object of known size close to others, horizontal and linear perspective (convergence of parallel edges), vertical position (objects higher in the scene generally tend to be perceived as further away), haze, desaturation, and a shift to bluishness – again usually in the distance – and the change in size of textured pattern detail.




**Edison's short-lived Vitascope, a re-badged system invented by others, but credited to him. Shortly after he produced his own version.**

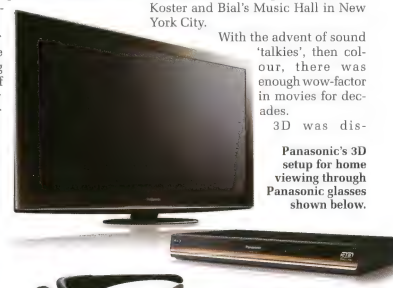
Finally, to dramatically reinforce the effects in 3D, objects are often filmed coming right at the viewer.

Edison was quick to harness the value of movies via his single-viewer Kinetoscope films, locking up much of the technology in patents for many years. Knowing the lucrative market was in cinemas, Edison made and promoted the Vitascope 2D motion picture projector. It was invented by Thomas Armat and C. Francis Jenkins. Edison agreed to manufacture the machine and films for it but only if it was advertised as a new Edison invention, the Vitascope.

The Vitascope's first theatrical exhibition was on April 23, 1896, at Koster and Bial's Music Hall in New York City.

With the advent of sound 'talkies', then colour, there was enough wow-factor in movies for decades.

3D was dis-



**Panasonic's 3D setup for home viewing through Panasonic glasses shown below.**

**Panasonic's integrated twin-lens 3D camcorder for professional use – claimed to be the world's first. 3D video is recorded to SDHC/SD memory cards – improved compression methods make this possible.**

played in various films like monster movies of the 1930s and beyond, in 'terrifying 3D', which relied on red and cyan cardboard glasses to create a painfully unconvincing effect. But despite some success, 3D never became mainstream.

In 1952 Cinerama came close to 3D, by projecting images from three synchronised 35mm projectors onto a huge, deeply-curved screen, with 146° of arc.

In Australia from 1960, the Regent Plaza cinema in Melbourne was adapted for Cinerama and I saw 'How the West was Won'. Filmed with an expansive panorama and every depth cue possible, it appeared nearly 3D at times.

Cinerama sound was played back from a full-coated 35mm magnetic film with seven audio tracks. Five tracks were reproduced behind the screen, plus two on the side and back of the auditorium. A sound engineer manually adjusted the sound levels between the surround speakers according to a script!

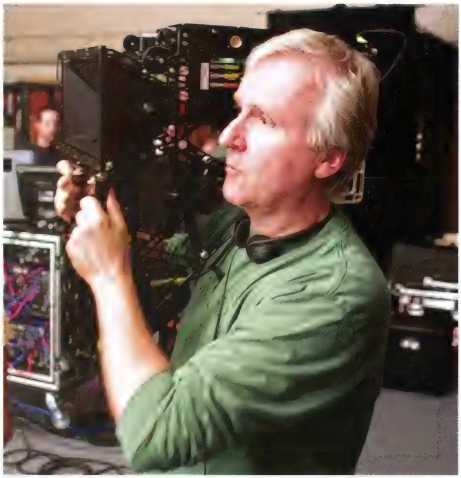
The projectors and sound system were synchronised using Selsyn motors.

## 3D still photography

As cinema tried to push 3D or super-wide imaging, there were many attempts at effective 3D still cameras. Most used a lenticular sheet coating on the prints or the vintage stereo viewer system.

Currently Fujifilm has a digital 3D still camera comprising two Fujinon lenses and two CCDs. Image data captured by the twin-lens CCD system is processed by the RP (Real Photo) Processor 3D – a newly developed processor that evaluates all photographic factors from focus and brightness to colour tonality, then merges the left and right images in a single 3D image.

The monitor on the 3D digital camera uses a 'Light Direction Control System', and the 3D digital viewer adopts a 'Parallax Barrier System' to precisely direct light to the right and left eyes in a way that simulates parallax. With the FinePix REAL 3D



**James Cameron, director of "Avatar", demonstrates one of the cameras used in filming the movie. Avatar is the first mainstream movie to make more income from 3D than 2D. Many theatres around Australia screen 3D, including iMax in Melbourne, the world's largest 3D screen.**

**Cinerama was an immense curved-screen format started in the 50s, with three projectors screening different images. With numerous depth cues, it was the nearest to 3D feel from a 2D format. (Turner Entertainment/Warner Bros.)**

**Sky TV in the UK conducted a 3D TV debut for the general public on January 31 2010, with a premier league football match shown on special 3D TVs in nine pubs across the UK. At left is some of the specialised equipment used in filming the match.**

system, you can review images in 3D on the camera's LCD monitor and also on the large LCD monitor of Fujifilm's 3D digital viewer.

Not all reviewers have been impressed but hopefully the technology will become more user-friendly.

Fujifilm 3D stills are printed as a precision sandwich of a high-resolution image, laminated with a lenticular sheet that creates the 3D effect.

Unfortunately this process is too high-tech for a home printer, so images are sent to a Fujifilm 3D lab in the US for enlargement. In their plant, advanced technology encodes and aligns the captured 3D image according to the pitch of micro lenses arranged in parallel rows on the lenticular sheet.

When viewed through the lenticular sheet (ie, a sheet with cylindrical parallel lenses), interlaced image data is separated into left and right images, so the left and right eyes see the respective images. The parallax disparity between the images is interpreted as a sense of depth.

## Anaglyph 3D

The whole image in an anaglyph is made of two colour 'layers' - one picture 'layer' for one eye in reds and one for the other eye in cyan (blue) shades. These two colours are used because they're opposites to each another.

So, when the viewer looks at the resulting image through the red and cyan filters in the glasses, each eye sees a different layer.

The separate pictures from each eye are sent to the brain where the 3D stereo image is formed.

This technique was used both for static images and films but it renders everything you view an annoying scape of either pure red or pure cyan.

## Philips lenticular 3D TV system

As mentioned above, in 3D prints, a lenticular lens layer provides a different view for each eye, because of the refractions on the surface of the screen. Philips used this principle with its 3D LCD screens, incorporating a parallax barrier over the top of the screen. The barrier is made of slits that only allow the viewer to see selective vertical lines of pixels from certain angles at any one time and therefore ensure that the viewer is seeing the two distinct images.

The main issues with this method is there are dead zones where the effect doesn't work and it's also more prone to giving headaches and eye strain. It's been overwhelmed by Sony and Panasonic's systems which represent the future of mainstream 3D in the home.

In recent years, some computer companies like HP have produced a 'reasonable' 3D effect from 2D on a normal monitor screen, driven by a powerful computer.

This was displayed at HP's innovation centre, Cooltown, in Singapore. If you are ever in Singapore, it's worth seeing.

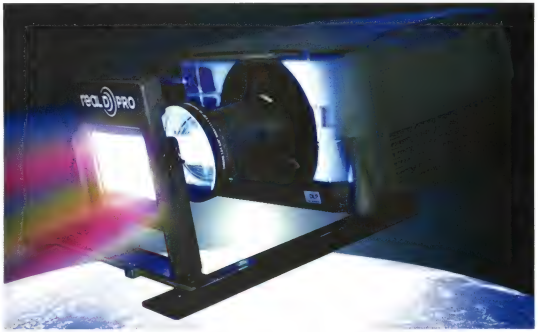
While HP's system delivers less dramatic 3D than systems with glasses, there are two big advantages: no glasses are needed and 3D is created from 'normal' footage.

## Dolby 3D in cinemas

Dolby's 3D for cinemas, also known as wavelength multiplex visualisation, is considered very effective but the required glasses are expensive and the system is unsuitable for home use. Dolby's 3D Infitec is one step up from anaglyphs and is in fact referred to as 'super-anaglyph'.

Instead of just splitting the two images into complementary colours, the points of view for each eye use narrow

**Fujifilm's 3D digital still camera is available now, however prints can only be made in their lab in USA.**




**The world's first mobile single-projector passive 3D solution. Designed to be set up for individual 3D presentations in minutes, or permanently mounted for long term use, the RealD LP allows the flexibility of switching between 2D and 3D on the fly. The RealD LP is externally mounted on a 3D-enabled DLP projector. When 3D content is fed to the projector, the RealD LP allows content to be seen in 3D by polarizing right- and left-eye images. Suitable for screens up to 17 feet wide, the RealD LP works with 3D-enabled projectors and requires a silver screen from MDI, Harkness or Stewart.**

but different bandwidths of blues, reds and greens. So the left and right eyes are actually seeing slightly different and distinct wavelengths of reds, blues and greens to each other but it's not noticeable with human perception.

The result is two entirely separate full colour images which can be decoded by sets of glasses with the appropriate filters. Infitec, used in the Dolby 3D system, works by putting special colour wheels in the projection lightbeam, which select the wavelengths of light it lets through.

The reasons why Dolby 3D is a strong contender for cinemas is that the projection screen doesn't have to be a specialised silver 3D type and Dolby 3D also provides brighter, more vivid colours, a sharper image with more detail, better contrast and almost no ghosting

A rotating filter wheel assembly is installed in the existing digital projector between the lamp and picture element for viewing 3D; it retracts for 2D presentations. Dolby's Filter Controller (DFC100) automatically synchronises the filter wheel with 3D digital content as it's projected.

## Circular polarising 3D

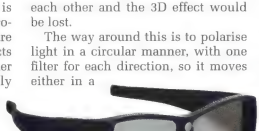
Polarised light was discovered in 1936 by Edwin H Land (of Polaroid fame) and is pivotal to the RealD Cinema system currently used in 80 percent of all 3D films, like Avatar. It is very effective and the glasses are inexpensive, however more complicated equipment is required for home use.

The most successful way to display 3D in cinemas was by polarising the two images. In the cinema, two projectors were used to produce synchronised images on the screen, providing right and left eye perspectives. The two projectors had opposite polarising filters over the lenses to ensure they only let through light travelling in one orientation.

The audience wore glasses with the same polarised filters. Then the two distinct and different pictures were sent from the eyes into the visual cortex where the brain put them together in 3D.

In the past, the easiest way to polarise the light was to send it linearly, either in the horizontal plane or the vertical one but that meant that if you tilted your head at an angle, the light from the two images would bleed into each other and the 3D effect would be lost.

The way around this is to polarise light in a circular manner, with one filter for each direction, so it moves either in a clockwise or anti-clockwise direction. Then it makes no difference which way you move your head.




**RealD CE5 Active Shutter 3D glasses. Active Shutter eyewear is used for 3D viewing when synchronized to a compatible display. Fast-response opacity in each lens and liquid crystal quality determines 3D image clarity.**

## RealD's 3D system

In the fast-moving world of 3D, one name rarely mentioned to consumers, yet behind 80% of 3D in movies and television, is RealD. For 30 years, RealD has provided key stereoscopic technologies used in science, manufacturing, marketing and other industries. RealD's technology is used by organisations such as NASA, Pfizer, BMW and Boeing. Now RealD's 3D movie technology is claimed to be used for 80 percent of movies in cinemas today, making 3D films like Avatar possible.

The main difference in RealD 3D is that it uses one projector to display the images for the right and left eyes, alternating at a speed of 144 times per second, so your eyes don't notice any flicker. RealD is a digital standard, meaning movies are recorded in digital format and the projectors are also digital.

The 3D polarised light method means glasses are relatively cheap but cinemas do require the projection of the image onto a quality silver screen to maintain the light's polarised state, rather than a white screen which would degrade it.

## RealD 3D TV

RealD has reached agreement with Sony, JVC, Samsung, Toshiba and Panasonic. Many of these companies

# IMAX 3D

It is hard to talk about 3D without mentioning this massive format. IMAX 3D uses large linear passive polarised plastic glasses for the viewers, with movies optimised for pop-out screen effect. Objects literally seem to leap out of the screen appearing as if you can touch them. Kids love this effect but it can be tiring in longer movies.

The IMAX cinema in Sydney's Darling Harbour has the world's largest cinema screen at 29.42m high by 35.73m wide – covering an area of more than 1,015 square metres. Made of vinyl coated with a reflective silver paint, the 3D screen is stretched taut over a scaffold frame. Thousands of small perforations allow sound from speakers positioned behind the screen to play their key role in the surround sound system.

IMAX 'conventional' films are shot and projected on 15 perforation/70mm film – the largest film format in existence. It's only possible to project these onto the huge screen because of the remarkable high-definition and clarity of the film frames.

**Close-up of a 15kW Xenon short-arc lamp. Photo: Atlant/Wikipedia.**

The powerful projector uses two 15,000 watt bulbs (see photo).

The average 35mm movie projector 'only' uses a bulb between 2,000 and 4,000 watts. The two lenses on the IMAX 3D camera see a slightly different view, as they are photographed simultaneously onto two separate rolls of film. In the cinema, the two films are projected as alternate frames at 96 times per second.

**IMAX 3D is filmed on cameras designed for each environment, like this camera for general use. When filming a feature on repairing the Hubble Space Telescope, only eight minutes of film could be loaded, using a custom-made IMAX camera as big as a submarine.**

SILICON CHIP published a feature explaining the intricacies of IMAX in the April 2003 issue.

will also work with RealD to develop premium active (shutter) glasses and passive glasses compatible with their 3D-enabled displays.

For video projection, the RealD LP (Linear Polarising) projection system is designed for home or business 3D and 2D presentations, for education, commercial and industrial applications. Screens up to five metres wide are possible and RealD LP works with 3D-enabled projectors plus silver screens from a number of manufacturers.

## LCD glasses

In the home, the main choice is likely to be the alternate image projecting system, utilising plasma or LCD TVs with a fast frame-rate and LCD shutter glasses, which incorporate a separate polarising filter for each eye. When a control voltage is applied to these glasses, the individual lenses alternate to black, thus obscuring each eye's view for a moment. The glasses are synchronised with the TV's frame-rate and controlled by an IR signal from the screen.

The market for 3D glasses (should we call them 3D specs?) will be hotly contested, with the top models made by XpanD and RealD.

## Technical uses for 3D

Designed for engineers, scientists, cartographers and medical professionals for viewing complex 3D computer graphics models, Monitor ZScreen 2000 and 2000i use Stereo3D technology to provide the most realistic representation possible. The Monitor ZScreen 2000 series is ideal for GIS/Mapping applications, molecular modelling and medical applications, particularly for dual display systems and small group visualisation.

The ZScreen panel is easily attached to a standard CRT computer monitor to deliver Stereo3D visualisation capabilities. In conjunction with stereo-ready software, Monitor ZScreen separates the left and right eye images.

Ultimately it may be the video gamers who get the most excited about 3D. Sony has announced a PS3 (PlayStation 3) 3D firmware update for stereoscopic games to come with their BRAVIA LCD TVs in 2010.

RealD is also set to be used in the upcoming Avatar game. The RealD Format allows for a direct connection between the Xbox 360 video game and entertainment system or PlayStation 3 computer and 3D-enabled TVs, for an unsurpassed 3D gaming experience.

## Pay TV 3D developments

In Australia, Foxtel has successfully trialled 3D in its labs and offices. It plans test broadcasts in 2011 and may announce a full 3D roll out soon after.

Global cable sports network ESPN plans to have trial 3D broadcasts from this year's World Cup in South Africa.

Channel Ten broadcast a brief 3D segment in the quiz show "Talkin' 'bout Your Generation" on February 7th. Ten gave away the disposable red and cyan 3D glasses in TV WEEK and Woman's Day magazines. This appears to be a test of public reaction to 3D broadcast through existing equipment. (3D by 3Dimages.com.au)

In the UK, Sky's 3D TV debut for the general public took place on January 31 this year, with a premier league football match shown on special 3D TVs in nine pubs across the UK.

Viewers reported: "It's brilliant, the corner and back of the goal views are just amazing. It makes the game so much better."

"It was phenomenal – far better than I thought it would be. You feel so involved in the game, part of the action. This is the way football should be seen."

"It just looks incredible on screen – really amazing, I think everyone is going to want to watch football in 3D now."

There was just one negative: If you step to the side or sit down, it gets a bit blurry.

Sky will be launching its 3D television channel this month (April 2010) by screening the Arsenal vs Manchester United match in nine pubs across the country. The game will be filmed by eight 3D camera rigs containing 16 3D cameras for stereoscopic shots from almost any angle.

A 3D production team and purpose-built 3D OB truck will allow mixing between cameras, replays, and 3D graphics. The 3D broadcast will have a dedicated commentary team.

## Free to Air

Channel Ten broadcast a brief 3D segment in the quiz show "Talkin' 'bout Your Generation" on February 7th. Ten gave away the disposable red and cyan 3D glasses in TV WEEK and Woman's Day magazines.

Channels Nine and Seven are also monitoring the 3D's impact, particularly on sport. But Seven's general manager of group broadcast services, Andrew Anderson, said it could be years before there was a large number of 3D television sets in Australian lounge rooms. Some retailers agree, noting the initial high cost of 3D TVs and consumer reluctance to buy another, when they have recently acquired flat-screen TVs.

The 2010 US International Consumer Electronics Show (CES) was the stage for many manufacturers' 3D product releases and demonstrations. Samsung's latest LED TV has a screen as thin as a pencil, just 7.6mm thick. The LED 9000 includes a 3D processor, 240Hz refresh rate and a TV built into the remote control, for simultaneous viewing of live television in the remote!

Samsung forecast it will sell 10 million LED TVs this year. LED backlights have replaced CCFL (Cold Cathode Fluorescent Lamp) backlights in many LCD TVs, as LEDs offer better colour saturation and power consumption than CCFL technology.

My observation is that LED is more vivid than the best LCD screens, however occasionally, LED screens do exhibit less shadow detail than others. Will this deter buyers? Absolutely not. Most viewers love an exaggeratedly colourful and vivid screen.

This 'Heroes of She' video clip on YouTube is claimed to be the world's first 3D music video.

Samsung's range includes a 55-inch LED TV. For people who want to watch regular 2D television shows in 3D, Samsung has included a 3D chip that renders 2D content into 3D in real time. The company also sells active shutter 3D glasses.

Chinese television manufacturer TCL took on the larger companies with the release of two 3D televisions – one that requires glasses and one that does not. The model which requires 3D glasses is a 240Hz LCD TV with an independent infrared device to communicate with the active shutter glasses. This 46-inch television features 1920 x 1080 resolution, 1000:1 contrast ratio and HDMI input plus a 4 millisecond response rate.

The television that does not need glasses, also known as auto-stereoscopic, uses a lenticular lens (not unlike Philips') which acts as a filter over the 1920 x 1080 screen. TCL, which is marketed in North America as RCA, is represented in Australia.

In Australia, Sony and Panasonic have both announced that 3D products will be available here within months. Earlier this year, Panasonic Australia announced their 3D camera for professional and serious amateurs, at around $20,000.

Also on show at the CES was the Panasonic 50-inch 3D Full HD Viera Plasma. It measures around 70mm thick and it is expected that 3D will only be featured on screen sizes of 50 inches and above. 3D images must be viewed through Panasonic's own battery-operated eyewear, which receives sync pulses via infrared from the TV.

Those watching the demonstration noted the 3D effect was OK when watching the screen from different angles.

In addition to the 3D TV, the 3D Blu-Ray player and the eyeware, consumers must also purchase an HDMI 1.4 cable. This effectively makes the consumer transition to 3D a four-product commitment.

Panasonic prices have not been announced but you can expect to pay between $5,000 and $8,000 for the whole package.

Sony's range will be released in July and will introduce free IPTV (Internet Protocol Television). Videos will be streamed directly from the internet to Sony TVs, with 15 channels available through its service, including made for internet content.

There will also be the ability to add pay-per-view movies or content in the future. Some models will include on-screen Internet Widgets to access real-time updates from applications such as Yahoo Weather, Yahoo News, Twitter, Facebook and Flickr.

Toshiba and Samsung have also announced 2D to 3D conversion systems with their sets.

## Plasma or LCD – another battle looms

Panasonic Australia recently declared, "Plasma is the ideal technology platform for 3D. Not only does it offer better image response, but deeper blacks provide superior contrast and a wider viewing angle ensures the 3D image is uncompromised."

As expected, Sony, who only produces LCD sets, has responded, with technology communications manager Paul Colley 'going to bat' for LCD. Because both Panasonic's and Sony's 3D technology is based on separate images produced for the left and right eyes, with a shutter in the eyeware alternatively opening and blocking each of the lenses, Colley said the speed of LCD gives it an advantage.

'When a different left and a right frame is transmitted, you're halving the amount of time the image is on the screen for, so that means TVs will need to be able to perform to a shorter refresh time,' explained Colley.

"The benefit of LCD is that we already have the 200Hz technology, so we can manage that short frame time and we can use that time also to eliminate the cross between left and right fields."

Colley also discussed polarisation. In LCD, this occurs at the TV end of the content delivery, whereas with plasma it occurs at the eyeware. Colley said the eyeware method causes flickering, with the line of sight around the television appearing blurred.

Panasonic counter-claimed that 3D on LCD cannot be viewed from low angles, such as when lying on the couch. Only time and technology will resolve which system is superior.

We can look forward to an escalating battle between brands on hardware, systems, software, release dates and prices.

The only certainties are, most home entertainment will have too many features, their 50+ page operating manuals will be near-impossible to follow and within a few months of purchasing equipment it will be superseded by models with more 'wow' factor! SC

**Sony's prototype single lens 3D camera with a frame-rate at 240fps (frames per second). A single lens captures the left and right images simultaneously.**

# WIB FAQs

**The Web Server In a Box (WIB) project has been very popular and lots of kits have been built. Here we collect a number of frequently asked questions that may help anyone experiencing difficulties in building and setting up the WIB. We also provide the answers to some common technical questions and feature requests.**

**By MAURO GRASSI**

## Software Releases

At the time of writing, the released firmware for the WIB includes versions between 5.30 and 5.40. Most questions in this article relate to versions 5.30, 5.31 and 5.32.

Version 5.40 is the latest and fixes two problems with earlier versions (see later). It has been made available to the kit suppliers and is also available for free download from the SILICON CHIP website. Future batches of kits should contain the new firmware version (5.40) or later.

This FAQ compilation refers to the original hardware of the WIB, which used the dsPIC33FJ64GP802 microcontroller. However, it is now possible to use the dsPIC33FJ128GP802 chip as well. This device is pin for pin compatible but has double the program memory.

By using this new chip, it would now be possible to incorporate many new features, including an ethernet-based bootloader. This and other features will be considered for a future upgrade to the WIB.

## Common Setting-Up Questions & Problems

**Q** I have changed a setting in the *settings.txt* file using a text editor but the setting does not seem to have changed in the WIB. Why is that?

**A** This can be confusing at first and is one of the most common traps that constructors can fall into.

Basically, the settings are stored in binary form in the *values.dat* file. The *settings.txt* file is only for the default values (if there is no values.dat file), as happens on the very first boot up.

The WIB creates the *values.dat* file from the *settings.txt* file if it does not exist. If it does exist, it uses the settings stored in the *values.dat* file.

This scheme made the firmware simpler because changes to settings can be stored easily in binary form but are more difficult to store in a human-readable file like the *settings.txt* file. However, the human-readable file is useful for setting up the default values.

In order to change the settings

to those in the *settings.txt* file, you need to first delete the *values.dat* file and then reboot the WIB. A new *values.dat* will then be created, with the settings taken from the *settings.txt* file. This is done by clicking the "Restore Defaults" button in the supplied default website (ie, you don't have to switch the WIB off and then on again in order to reboot it).

**Q** There is a *csettings.txt* file in the supplied default website, as well as the default *settings.txt* file. What is the *csettings.txt* file for?

**A** The *csettings.txt* file is generated by the WIB and should not be modified, as it has no effect on the settings of the WIB. The *csettings.txt* file is created by the WIB at runtime to store the current settings in a human readable form. This is used in the "Create Defaults" function, where the *csettings.txt* file is copied to the *settings.txt* file.

**Q** Should I retain the directory information when I unzip the contents of *ewswebsite.zip* to obtain the supplied website (available from the January 2010 downloads section of the SILICON CHIP website)?

**A** No, the files should all be unzipped into the root folder of the memory card disregarding any original path information stored in the zip archive.

**Q** There is a file named *0711109A.hex* in the supplied default website, what is this file for?

**A** This file contains the firmware image for the latest version of the WIB. It can be left on the memory card and will not affect the operation of the WIB or it can be deleted. It is a small file, so it will not take up much space on the memory card. Note that if it is left on the memory card, it can then be accessed like other pages served by the WIB.

**Q** I am having trouble logging in to the WIB with the username and password as set in the *settings.txt* file. Alternatively, some setting in the *settings.txt* file does not seem to be being parsed properly. Why is that?

**A** There could be a number of reasons for not being able to log on to the WIB using the username and password as stored in the *settings.txt* file. First, as explained earlier, the *settings.txt* file contains the default values, not the actual values of the WIB. The actual settings are stored in binary form in a file called *values.dat*.

If you wish to revert to the settings in the *settings.txt* file, you should delete the *values.dat* file and reboot the WIB as explained earlier.

Additionally, when the WIB reads the values from the *settings.txt* file, it will only parse a line if it finds a newline at its end. So a setting may not be being parsed simply because there is no newline at the end of the line (this happened to a reader). Remember every entry in the *settings.txt* file should be on a separate newline-terminated line.

So if you can't log on with the username and password in the *settings.txt* file, it may be because the last line in the *settings.txt* file does not contain a newline. In the default *settings.txt* file supplied, the password setting is last. While the file supplied has a newline, if you change this line, the last line may no longer have a newline and so the password will not be set.

**Q** The WIB seems to be working correctly but it cannot send emails. There is an entry in the *log.txt* file with a hexadecimal error code. What does this mean?

**A** The hexadecimal error codes shown in the *log.txt* file relating to sending emails are standard SMTP (Simple Mail Transfer Protocol) error codes. These are returned by the SMTP server that the WIB is connecting to.

For example, if your ISP is Telstra, you would be receiving an error code from the Telstra SMTP server and likewise with Optus and other providers. The list of SMTP error codes can be found online.

The "Email From" may also need to be set if you are using your ISP's SMTP server and are sending the email to a foreign email address, specially to a Gmail or Hotmail address. If not set correctly, an additional error may occur because of some SMTP server anti-relaying rules to do with spam reduction.

The relevant error is 0x0227 (Error 551). We found this during testing with the Telstra SMTP server, for example. Changing the "Email From" field may solve this problem. Remember the "Email From" field is simply what is shown as the Sender when you receive an email from the WIB, so it is not a crucial setting.

Note that SMTP settings for "Email Server User" and "Email Server Password" are only used if the SMTP server you are sending to requires authorisation. Most ISP SMTP servers don't require this (so you can send anonymous emails when you have an internet account) but some do require authorisation.

If the Email User and Password settings are set, the WIB starts an SMTP session by trying to authenticate with the server. If the SMTP server doesn't require this, then it may terminate the SMTP connection before the email is sent, returning an 0x01F7 error (Error 503), even if the username/password is correct.

To avoid this problem, remove the two settings from the *settings.txt* file, delete the *values.dat* file and reboot the WIB.

**Q** When I try to log on to the WIB using its IP address from the address bar of my web browser, it loops continually without loading the home page. Why is that?

**A** When you type the IP address into a browser, without qualifying any extra path information, it assumes as default that you are requesting the *index.htm* file. The *index.htm* file provided with the default website for the WIB uses the refresh metatag to redirect to the home page, which is the *home.cgi* page.

On some web browsers or on some versions of those browsers, this has the effect of looping continually without loading the page. Specifying the complete path (eg, 192.168.0.34/home.cgi) rather than only the IP address should solve this problem. Alternatively, changing the contents of the *index.htm* page can solve the problem.

**Q** Can the microcontroller in the WIB be programmed using the dsPIC/PIC Programmer described in

the May 2008 issue? If not, how can it be programmed?

A No, the dsPIC/PIC Programmer cannot program the dsPIC33-FJ64GP802. The latter microcontroller was not available at the time the programmer was designed and so is not supported. Instead, it is best to use a programmer like the PICkit3 from Microchip together with their free MPLAB software.

Q Can you give an example of what values are needed for connecting a straight 0-5V sensor to the analog inputs of the WIB rather than a 3.3V sensor as described in the original article?

A You will need to connect your sensor to a voltage divider to bring its output within a 0-3.3V range. This can be done by connecting a divider that divides by 5/3.3 = 1.52 (eg, 10kΩ and 20kΩ).

You will then need to calculate the correct values for your sensor and enter them in the gradient and Y-intercept fields in the *variables.cgi* page of the default website.

The instructions to calculate these values are in the original articles.

Q The LM317 voltage regulator used to derive the 3.3V rail for the WIB runs hot to the touch. Is this normal and how can the heat be reduced?

A It is normal for the regulator to get hot and so the original design specifies a heatsink. The higher the input voltage delivered by the plugpack the more heat that will be dissipated. To reduce the heat dissipation, you should use a 6V plugpack.

Q Can the WIB take digital inputs? Can the WIB send an email notification when a digital input changes? For example, can the WIB send an email notification when a reed switch closes or opens?

A While nominally the WIB only accepts four analog inputs, they can also be used to accept digital inputs. If the digital input swings between 0V and 3.3V, it is easy to set the minimum and maximum values at about the middle of this range. However, the minimum should be below the maximum to allow for hysteresis.

The WIB can then send emails when the state of the digital input changes. If using a reed switch, you do the same but use a pull-up resistor to the 3.3V rail or a pull down to 0V. If the digital input is not within a 0-3.3V range, you will have to implement some kind of level translation. This can sometimes be easily achieved by using an open collector output and a pull-up resistor to the 3.3V rail.

Q Can the digital outputs of the WIB be pulsed for a determinate amount of time?

A Not with the current versions of the firmware, although this could easily be incorporated if sufficient program memory were available. You could have an extra variable (or four extra variables for independent control) to hold the pulse time in milliseconds and new commands to pulse the outputs.

These are easy additions to the firmware but there is not enough program memory to make the modification with the original hardware. It is certainly possible with the 128KB version chip and may be incorporated in a new design in the future. If readers really want this function, they could delete parts of the code to make room for it.

Q Can the WIB be used with Windows based FTP programs? In particular, can it be used with programs such as FileZilla?

A With versions of the firmware before 5.40 some FTP programs like FileZilla did not like the WIB's response to the PWD command. This was fixed in firmware version 5.40 in response to a reader's report. In any case, versions without this fix should still work with the recommended FTP command line Windows client, as explained in the original article.

Note that the WIB is not guaranteed to work with other FTP clients because it does not support the full FTP command set.

## USB Support & File System Storage

Q Are there any plans to make the WIB work with an NTFS file system?

A No, there are no plans to make the WIB support file systems other than FAT. As NTFS is primarily a Windows file system, you would lose the portability that FAT offers.

Note that you can read FAT with either a Windows or Linux PC and with a Mac. Also, there is little appreciable gain in performance in going from FAT to NTFS for the WIB project (there is for a PC though).

FAT is perfectly adequate for the WIB (it is limited to 2TB but there is not going to be an MMC/SD/SDHC memory card that can store 2TB any time soon!) It is true that there is also a single file size limit with FAT that would be much less restrictive with a newer file system like NTFS. However, the limit is around 4GB and we think this is more than adequate for the application.

If you are going to serve a page of that size it will take a considerable amount of time using the WIB – it is a huge amount of data.

There are also licencing issues with NTFS that are avoided with a FAT file system as used in the WIB (there are issues with FAT too). The FAT code used in the WIB is open source and the NTFS code would also certainly have a larger memory footprint.

NTFS is suitable for modern operating systems running on PCs with abundant resources but it is much less suitable for embedded systems with few resources like the WIB. For all these reasons, FAT is a good choice as a file system for the WIB and for many other embedded systems.

Q Can a USB flash drive be used to store website files for the WIB instead of using an MMC/SD/SDHC memory card? If not, are there any

plans to modify the WIB to do this?

A To interface to a USB flash drive would require implementing a USB host interface, including a supply to power the USB. The WIB does not have the hardware to do this. For this reason, it would not be viable to modify the WIB to support a USB flash drive.

We believe a memory card is adequate for the application and has the advantage of being quite compact. USB flash drives are perhaps more easily transported and removed but in this application, we assume that the memory card will be seldom removed.

Q Are there any plans to make the WIB work with an external hard drive, either via a USB port or natively?

A No, there are no plans to change the WIB's mass storage from its current medium. We believe that the current capacities that can be purchased in SDHC cards (up to 32GB) are more than sufficient for the applications that the WIB will be used for.

While hard drives offer cheaper and larger storage capacities, the complexity of the interface rules it out for the WIB. The microcontroller has no native USB host support and there is no other hardware on the WIB to support connection to a USB device. Adding a native hard drive interface would be even more complex.

Added to this, a memory card uses less power and is more compact, reliable and faster than a hard drive.

Q Can the WIB be used with 3G wireless modems with a USB port (dongles)?

A No, since the WIB does not implement a USB host, it cannot be used with such 3G modems. The WIB can only be used with an ethernet connection.

To be able to use a USB modem, you would need a USB host and the WIB has no such hardware support as it stands. However, there are 3G wireless modems which have an ethernet connection and you should be able to use such a modem with the WIB.

## Miscellaneous Questions

Q Is it possible to put a slot in the external case so that the memory card can be removed or inserted without having to take the case apart to get at the card?

A When the design was conceived, we assumed that the memory card would only infrequently be inserted or removed, as files can be uploaded or downloaded using an FTP client. It would be possible to house the WIB in a different case with a slot that would allow easier access to the memory card. In fact, you could even use it in a freestanding manner without a case, or leave out one of the side panels if you use it with the originally specified case.

Q The RJ45 connector from Amphenol used in the WIB (CON2) has pins 4 & 5 and pins 7 & 8 each internally shorted and then connected via 75Ω resistors to a single 1nF capacitor connected to 0V. Would this cause problems if it were connected to a PoE (Power over Ethernet) system? Wouldn't some of the 75Ω resistors be destroyed?

A The termination used in the WIB is the one recommended in the datasheet for the ENC28J60 ethernet controller (obtained from the Microchip website). The 75Ω resistors and the 1nF capacitor are for EMI reduction and ESD protection and the 1nF (2kV) capacitor connects to the metal shield of CON2 for this purpose.

The RJ45 connector used in the WIB is not designed for PoE applications and it would be a problem if the PoE host simply applied power. But that doesn't happen – PoE hosts test the resistance between the terminals before doing so.

In other words, a device configured for PoE must have the correct resistance before it is supplied with power. Since the WIB doesn't present the correct resistance, the PoE host will not (or should not) apply power to it (an RJ45 connector for PoE would add capacitors in series with the 75Ω resistors).

## Serial Port Questions

Q Can data be logged from the serial port of the WIB?

A You cannot log data from the serial port using the current versions of the WIB firmware. However, you can log data from the four analog inputs to the SD card and email them to a nominated account.

Q Is it possible to communicate in both directions with the on-board serial port of the WIB?

A No, it is not possible with current versions of the firmware to receive serial data with the WIB.

It would not be difficult to modify the source code to allow the WIB to receive data into a buffer or to write it to a file on the memory card, perhaps with network time information as well. You could also build in a serial server that would listen to serial commands and run functions, depending on the received data. For example, you could have the WIB send an email every time a certain sequence of serial data is received or send the serial data received in an email.

When the firmware was written, program memory was at a premium and some features had to be dropped. The serial port functions for sending data and now taking up memory could perhaps be replaced with code for receiving data.

## Website Functionality Questions

**Q** Can the WIB firmware be easily modified to include support for PHP and ASP server-side scripting?

**A** No, it is not possible – the WIB supports only client side scripting. Server-side scripting is intended for more powerful PC-based or embedded servers but is not really suitable for the WIB. We cannot rule out some kind of server-side scripting for a future upgrade but it may not be on the scale of a full-featured language like PHP, simply because the hardware is not powerful enough.

**Q** Is it possible to use a typical LAMP (Linux, Apache, MySQL, PHP) installation with the WIB?

**A** No, it is not possible. Such installations are for full-featured PC-based or embedded servers that are much more powerful than the WIB. The WIB is not a full-featured server, nor does it have the speed or memory (or even hardware architecture) to run such an installation.

**Q** Can the WIB support a website for online shopping using a shopping cart?

**A** No, the WIB does not support a shopping cart application. There are a number of reasons. First, it does not support server side scripting and second, it would not be ideal from a security point of view as the WIB does not support encryption either.

## Feature Requests

**Q** Does the WIB respond to ping requests? Does the WIB implement a DHCP client?

**A** No, the WIB does not support ICMP and will not reply to ping requests. Early versions of the firmware supported ping but that was dropped to make room for other features due to limited memory.

DHCP client support was also dropped for the same reason.

**Q** How can the firmware be updated if there are future changes?

**A** Currently, the only way to do this is to use a PICkit3 programmer. This is because the WIB doesn't have a bootloader which would allow its program memory to be rewritten with an upgraded version of the firmware via an ethernet connection. The microcontroller supports RTSP (Run Time Self Programming) but there was simply not enough program memory to implement such a feature.

However, as stated at the beginning of this article, it is possible to use the dsPIC33FJ128GP802 chip instead of the original microcontroller. This latter device is pin-for-pin compatible but has double the program memory. By using this chip, it would be possible to incorporate many new features, including an ethernet-based bootloader and we may make this feature available in a later version of the project.

**Q** What are some of the feature requests that have been submitted by readers? Will they be implemented in the future?

**A** Several readers have modified the firmware so that it does not delete the variable log files on reboot and to immediately log the variables on reboot, without waiting for the first log interval to elapse. Some readers have also added extra digital outputs and inputs via extra hardware, although the four analog inputs can also be used as digital inputs.

There are no plans at the moment to incorporate these features in the standard firmware for the WIB.

**Q** What are some of the feature requests that you have received from readers and which of those are viable? What other add-ons are possible?

**A** We have had many requests from readers for features. Among these are:

(1) Better security, using encryption at least for the HTTP headers;
(2) Support for server-side scripting like PHP;
(3) Connection of additional sensors, including perhaps digital interfaces for sensors (eg, 1-wire Dallas);
(4) Battery backed-up power supply, including a mechanism to monitor mains voltage;
(5) Using the WIB for controlling a number of mains powered appliances (eg, to power cycle computers through the web server);
(6) A bootloader to allow for easy firmware updates;
(7) Faster ethernet connection and WiFi (wireless) connection.

The ones that we think are viable are (1), (3), (5), (6) and we could also add DHCP client support and ICMP support. Server-side scripting of some form could be incorporated but almost certainly not in the form of PHP, so we think that (2) is not viable.

We think that (4) is too specialised and thus not viable. Note that many computers can be woken up using their LAN interface remotely (wake-on-LAN), so (5) would really only be for controlling mains devices other than PCs with a wake-on-LAN feature.

Note that the Microchip TCP/IP stack is also fully integrated with WiFi support and Microchip also supplies the hardware for WiFi. As such, WiFi is also possible but would depart from the original design substantially.

Again, although Microchip also now provide a 100Mbps ethernet controller, it comes in an SMD package which would thus also depart from the original design substantially, so (7) is probably not viable (it would be a new hardware project).

When you exclude firmware features, there are also many other hardware add-on boards that could be designed. The WIB Time Display Module published in the February 2010 issue of SILICON CHIP is one such item and one reader has used an LCD rather than a LED display, with good results.

## Source Code Requests

**Q** I want to experiment with the source code. Are you going to make it available on your website? What software is required to compile the source code? What hardware is required to reprogram the microcontroller with a newer firmware version?

**A** The source code for the WIB was written in C and was compiled using the full version of the Microchip C30 compiler (kindly donated by Microchip). The full version allows all optimisations and makes the code fit with the original hardware.

The code will not fit if using the free version of the Microchip C30 compiler (at least at time of writing, with current versions of the compiler). The source code will not be made available on the SILICON CHIP website but has been released to many readers on a case-by-case basis with certain conditions (ie, the code can only be used for personal, non-commercial use).

The free MPLAB software suite from Microchip (**www.microchip.com**) can be used as an IDE (Integrated Development Environment) and to program the microcontroller in-circuit using a programmer like the PICkit3 (also available online from Microchip). MPLAB also supports other programmers.

The microcontroller can also be programmed on a breadboard or in a ZIF socket. Future versions of the firmware may include an ethernet bootloader to allow the firmware to be easily updated without using a programmer.

## Known Bugs & Errata

**Q** Are there any known bugs and workarounds for the WIB?

**A** Yes there are two known problems with firmware versions that are fixed in version 5.40.

The first problem occurs when using an IP address for the WIB other than 192.168.0.x, eg, a 10.1.1.x address. Most people will be using a 192.168.0.x address so this issue will not be apparent.

If you assign an IP address other than 192.168.0.x, the WIB does not correctly ask for login information for file extensions set to private, exposing a security risk. For example, the *settings.txt* file can be viewed without logging in (the settings cannot be changed, however). Version 5.40 fixes this problem.

This problem can also be fixed by changing the default file permission to private (the default is public). This workaround works except that *all* files will then be private. If you want some to be public and some private, you will have to update the firmware.

The other problem is more minor and is also fixed in version 5.40. It simply adds quotes around the PWD command reply of the WIB's FTP server. This is necessary to prevent some FTP programs from reporting errors with the WIB's response. Note that the command-prompt FTP client supplied with Windows can still be used with the WIB to transfer files to and from a PC.

## ISP Terms Of Use

Please be aware that serving web pages may contravene your internet plan's terms of use. You should check your ISP's terms to ensure that the WIB can be used with your account.

In some cases, it may be necessary to get a business account or a static IP address. SC

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# A CAPACITOR LEAKAGE ADAPTOR FOR DMMS

By JIM ROWE

*Here's a cut-down version of the Digital Capacitor Leakage Meter we described in December 2009. Instead of using a PIC microcontroller and an LCD panel to display the leakage current, this version connects to your DMM to provide the readout. It provides the same range of seven different standard test voltages (from 10V to 100V) and can measure leakage currents down to 100 nanoamps!*

**Why would you need to measure** capacitor leakage current? In case you missed the December 2009 article, here's a summary of the introduction we provided there.

In theory, capacitors are not supposed to conduct direct current apart from a small amount when a DC voltage is first applied to them and they have to 'charge up'.

With most practical capacitors using materials like ceramic, glass, polyester or polystyrene - even waxed paper - as their insulating dielectric, the only time they do conduct any DC is during charging. That's assuming they haven't been damaged, either physically or electrically. In that case they may well conduct DC as a steady 'leakage current', showing that they are faulty.

But as many SILICON CHIP readers will be aware, things are not this clear cut with electrolytic capacitors, whether they be aluminium or tantalum. All brand new electrolytic capacitors conduct a small but measurable DC current, even after they have been connected to a DC source for sufficient time to allow their dielectric oxide layer to 'form'. In other words all electrolytic capacitors have a significant leakage current, even when they are 'good'.

The range of acceptable leakage current tends to be proportional to both the capacitance and the capacitor's rated voltage. Have a look at the figures given in the Leakage Current Guide opposite. The current levels listed there are the maximum allowable before the capacitor is regarded as faulty.

So an instrument capable of measuring the leakage current of capacitors can be very handy in many areas of electronics.

Commercially available capacitor leakage current meters are expensive (ie, over $1000) and even the Capacitor Leakage Meter we described in the December 2009 issue will probably cost you over $100 to build. That's why we've developed a cut-down version described in this article, which lets you make all of the same measurements with your existing digital multimeter (DMM).

The Adaptor is easy to build and will have a much lower cost than the December 2009 meter while still providing the same choice of seven different standard test voltages: 10V, 16V, 25V, 35V, 50V, 63V or 100V. It is also able to make current measurements from 10mA down to a fraction of a microamp. So it's capable of making leakage current tests on the vast majority of capacitors in current use.

It's built into a compact UB1 size jiffy box and is battery powered (6 x AA alkaline cells). This makes it suitable for the workbench or the service technician's tool kit.

## CAPACITOR LEAKAGE CURRENT GUIDE

| TYPE OF CAPACITOR | Maximum leakage current in microamps (μA) at rated working voltage | | | | | | |
|---|---|---|---|---|---|---|---|
| | 10V | 16V | 25V | 35V | 50V | 63V | 100V |
| Ceramic, Polystyrene, Metallised Film (MKT, Greencap etc.), Paper, Mica | LEAKAGE SHOULD BE ZERO FOR ALL OF THESE TYPES | | | | | | |
| Solid Tantalum* < 4.7μF | 1.0 | 1.5 | 2.5 | 3.0 | 3.5 | 5.0 | 7.5 |
| 6.8μF ⋮ 47μF | 1.5 ⋮ 10 | 2.0 ⋮ 10 | 3.0 ⋮ 15 | 4.0 ⋮ 16 | 6.5 ⋮ 17 | 7.0 ⋮ 19 | 9.0 ⋮ 24 |
| Standard Aluminium Electrolytic# <3.3μF | 5.0 | 5.0 | 5.0 | 6.0 | 8.0 | 10 | 17 |
| 4.7μF ⋮ 10μF | 5.0 | 5.0 ⋮ 8.0 | 6.0 ⋮ 13 | 8.0 ⋮ 18 | 12 ⋮ 25 | 15 ⋮ 35 | 23 ⋮ 50 |
| 15μF ⋮ 100μF | 8.0 ⋮ 50 | 11 ⋮ 230 | 19 ⋮ 300 | 25 ⋮ 330 | 38 ⋮ 420 | 100 ⋮ 500 | 230 ⋮ 600 |
| 150μF ⋮ 680μF | 230 ⋮ 500 | 280 ⋮ 600 | 370 ⋮ 780 | 430 ⋮ 950 | 520 ⋮ 1100 | 600 ⋮ 1300 | 730 ⋮ 1560 |
| 1000μF ⋮ 4700μF | 600 ⋮ 1300 | 730 ⋮ 1590 | 950 ⋮ 2060 | 1130 ⋮ 2450 | 1340 ⋮ 2900 | 1500 ⋮ 3300 | 1900 ⋮ 4110 |

* Figures for Solid Tantalum capacitors are after a charging period of one minute.
\# Figures for Aluminium Electrolytics are after a charging/reforming period of three minutes.

## How it works

The Adaptor's operation is straightforward, as you can see from the block diagram of Fig.1. There are two functional circuit sections, one being a selectable DC voltage source (on the left) which generates one of seven different preset voltages when the TEST button is pressed and held down.

The second section is a simple current to voltage converter (on the right) which is used to generate a voltage proportional to the direct current passed by the capacitor under test, so that it can be measured easily using your DMM.

Any direct current passed by the capacitor being tested flows down to ground via resistor R2, which therefore acts as a current shunt. The voltage drop across R2 is then passed through an output buffer which feeds your DMM. The DMM is set to its 0-2.0V DC voltage range, which allows its readings to be easily converted into equivalent current levels.

So that's the basic arrangement. The reason for resistor R1, in series with the output of the test voltage source, is to limit the maximum current that can be drawn from the source, in any circumstances. This prevents damage to either the voltage source or the current-to-voltage converter sections, in the event of the capacitor under test having an internal short circuit. It also protects R2 and the output buffer from overload when a capacitor (especially one of high value) is initially charging up to one of the higher test voltages.

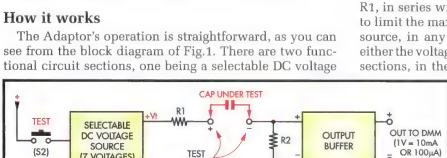



**Fig.1: block diagram of the adaptor shows it has two elements: a selectable DC voltage source and a simple current-to-voltage converter.**

R1 has a value of 10kΩ, which was chosen to limit the maximum charging and/or short circuit current to 9.9mA even on the highest test voltage range (100V).

At this stage you may be wondering

how the Adaptor can allow your DMM to read leakage currents down to less than a microamp, when it also has to cope with charging currents of up to 9.9mA. The answer is that the current-to-voltage converter section of the Adaptor actually has two current ranges, which are selected by switching the value of shunt resistor R2.

The default value of R2 is 100Ω, which provides a 0-10mA range for the capacitor's charging phase (ie, when TEST button S2 is first pressed). But when (and if) the measured current level falls below 100µA, pushbutton S4 can be pressed to switch the value of R2 to 10kΩ, providing a 0-100µA range for more accurate leakage current measurement.

## Circuit description

Now have a look at the full circuit schematic of Fig.2. The selectable DC voltage source is based around IC1, an MC34063 DC/DC controller IC, used here in a 'boost' configuration in conjunction with autotransformer T1 and fast switching diode D2.

We vary the circuit's DC output voltage by varying the ratio of the voltage divider in the converter's feedback loop, connecting from the cathode of D2 back to IC1's pin 5 (where the voltage is compared with an internal 1.25V reference).

The 270kΩ resistor forms the top arm of the feedback divider, while the 36kΩ and 2.4kΩ resistors from pin 5 to ground form the fixed component of the lower arm. These give the divider an initial division ratio of 308.4kΩ/38.4kΩ or 8.031:1, to produce a regulated output voltage of 10.04V. This is the converter's output voltage when selector switch S1 is in the '10V' position.

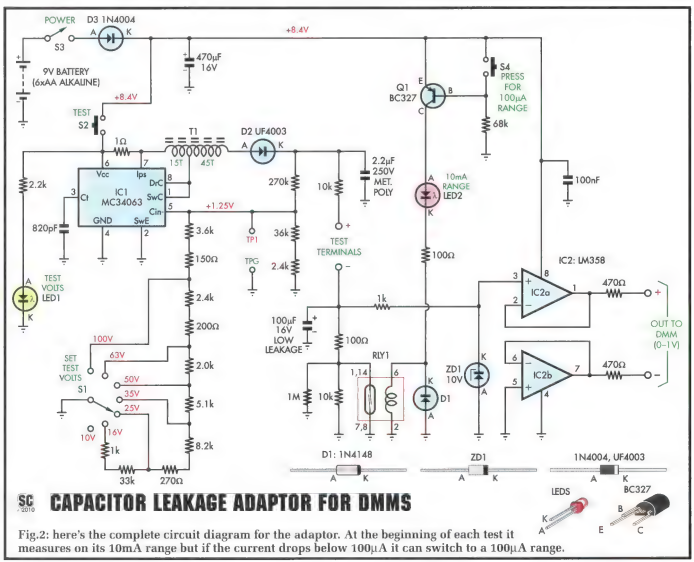
When S1 is switched to any of the other positions, additional resistors are connected in parallel with the lower arm of the feedback divider, to increase its division ratio and hence increase the converter's output voltage.

For example, when S1 is in the '25V' position, this connects the 270Ω, 8.2kΩ, 5.1kΩ, 2.0kΩ, 200Ω, 2.4kΩ, 150Ω and 3.6kΩ resistors (all in series) in parallel with the divider's lower arm, changing the division ratio to 283.954kΩ/13.954kΩ or 20.35:1. This produces a regulated output voltage of 25.44V.

The same kind of change occurs in the other positions of S1, producing the various preset output voltages shown.

(Although the test voltages shown are nominal, with the specified 1% tolerance resistors used for the divider resistors, they should all be well within ±4% of the nominal values because the 1.25V reference inside the MC34063 is accurate to within 2%.)

Note that IC1 only generates the selected test voltage




SC 12/2010

# CAPACITOR LEAKAGE ADAPTOR FOR DMMS

**Fig.2: here's the complete circuit diagram for the adaptor. At the beginning of each test it measures on its 10mA range but if the current drops below 100µA it can switch to a 100µA range.**

when test pushbutton S2 is pressed and held down. This is because IC1 only receives power from the battery when S2 is closed, allowing the converter circuit to operate and thereby charging the 2.2µF/250V metallised polyester reservoir capacitor. The test voltage is then made available at the positive test terminal via the 10kΩ current limiting resistor, R1.

Now let us look at the current-to-voltage converter section, which is virtually all of the circuitry below and to the right of the negative test terminal.

The 100Ω, 1MΩ and 10kΩ resistors connected between the negative

## Specifications

**Test voltages:** ..... 10V, 16V, 25V, 35V, 50V, 63V or 100V.

**Leakage current:** ..... from 10mA down to less than 100nA (0.1µA), via two ranges:

0-10mA (default) and 0-100µA (manually selected).

Both ranges convert these current values into an output voltage range of 0-1000mV DC, allowing all measurements to be made on the DMM's 0-1V or 0-2V range.

The Adaptor's default 10mA range is current limited to provide protection from damage due to shorted capacitors or the charging current pulse of high-value capacitors.

**Power:** ..... Internal 9V battery (6 x AA alkaline cells).

**Current drain:** ..... Varies between 1mA and 125mA, depending on the test voltage and the current range in use.

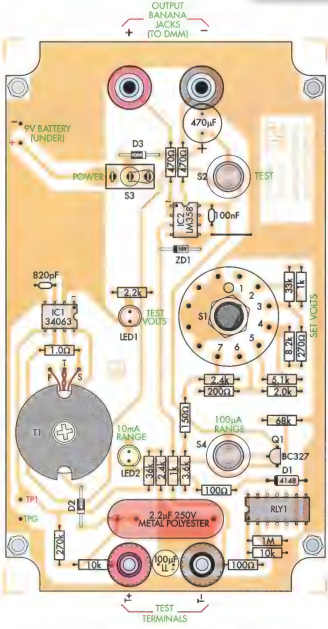



Fig.3: with the exception of the test terminals, DMM output jacks and three of the switches, all components mount on one PC board.

Here's a photograph which matches the diagram at left. In this case, the terminals and the two push-button switches are not shown on the board because they mount on the front panel and connect to the PC board via short lengths of tinned copper wire (one of the last steps in assembly).

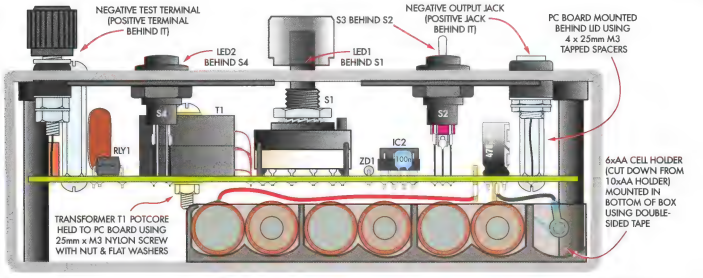



**Fig.4: a side-on view "through" the wall of the jiffy box, showing how everything goes together. The 6xAA cell holder must be mounted at one end, as shown here, to avoid fouling the screw holding the transformer to the PC board.**

test terminal and ground correspond to the current shunt labelled R2 in Fig.1, with the contacts of reed relay RLY1 used to change the effective shunt resistance for the Adaptor's two ranges. For the default 0-10mA 'charging phase' range RLY1 is energised and connects a short circuit across the parallel 1MΩ/10kΩ combination, making the effective shunt resistance 100Ω. For the more sensitive 100uA range RLY1 is turned off, opening its contacts and connecting the parallel 1MΩ/10kΩ resistors in series with the 100Ω resistor to produce an effective shunt resistance of 10kΩ.

Relay RLY1 is turned on or off by transistor Q1. When power is first switched on via switch S3, Q1 is switched on by forward bias current applied to its base via the 68kΩ resistor to ground. It therefore conducts about 10mA of collector current, which energises RLY1 and also causes LED2 to light – indicating that the Adaptor is operating in the 10mA current range. But if the capacitor's current reading (on the DMM) drops down to below 100μA, pressing pushbutton switch S4 and holding it down causes Q1 to switch off. As a result LED2 and RLY1 both turn off as well, switching the Adaptor to its 0-100μA range.

The 100μF low leakage capacitor in parallel with the shunt routes any AC signal from the capacitor being tested around the shunt. This prevents ripple from the switch-mode supply from corrupting the reading.

Regardless of which current range is in use, the voltage drop developed across the shunt resistance (as a result of any current passed by the capacitor under test) is passed to the non-inverting input of IC2a, one half of an LM358 dual op amp. IC2a is configured as a voltage follower with a voltage gain of unity, feeding the positive output terminal of the Adaptor via a 470Ω isolating resistor.

So what is the purpose of IC2b? It is connected as a voltage follower in much the same way as IC2a, except that its non-inverting input is connected directly to ground and its output is used to drive the negative output terminal. Its purpose is to balance out most of the input offset of IC2a, so that the Adaptor's effective output voltage, when there is no current flowing through the test terminals, is much less than 1mV.

All of the Adaptor's circuitry operates directly from the 9V battery, via polarity protection diode D4 and of course S3. The total current drain when in 'standby' (ie, with TEST button S2 not pressed) is about 11mA in the default 10mA current range or 1mA if S4 is pressed to switch it into the 100μA range. The current level increases to between 25mA and 125mA when S2 is pressed and held down to generate the test voltage and perform the actual leakage current test.

## Construction

Virtually all of the circuitry and components used in the Capacitor Leakage Adaptor are mounted on a single PC board measuring 145 x 84mm and coded 04104101. This is mounted under the lid (which becomes the Adaptor's front panel) of a UB1 jiffy box (157 x 95 x 53mm) via four 25mm long M3 tapped spacers. Six AA alkaline cells provide power, mounted in a cut-down 10-cell holder secured to the bottom of the box.

Both the voltage selector switch (S1) and the DC/DC converter's step-up transformer (T1), wound on a 26mm ferrite pot core, mount on the board, the latter using a 25mm long M3 Nylon screw and nut.

The only components not mounted directly on the main board are power switch S3, pushbutton switches S2 and S4, the two test terminals and the two output banana jacks. These are all mounted on the box front panel, with their rear connection lugs extended down via short lengths of tinned copper wire to make their connections to the board. All of these assembly details should be fairly clear from the diagrams and photos.

To begin fitting the components on the PC board I suggest you fit the wire link, located just to the right of the position for rotary switch S1. Next fit the four 1mm terminal pins to the board – two for the test point at upper left and two at upper right for the battery clip lead connections. Follow these with the sockets for IC1 and IC2, which are both 8-pin devices.

Now fit the fixed resistors. These are 1% tolerance metal film components, apart from the 1.0Ω resistor just to the right of T1 and to the left of IC1. This resistor should be a 0.5W carbon composition type. Check each resistor's value with a DMM as you insert and solder them to ensure they all go in the right places.

Next, you can fit the two lower-value capacitors and the

large 2.2µF metallised polyester capacitor, followed by the (polarised) 470µF electrolytic.

Then fit the mini DIL relay, making sure its locating groove is at the top end. Then you can fit voltage selector switch S1, which mounts with its indexing spigot at 3-o'clock. Just before you fit it you should cut its spindle to a length of about 13mm and file off any burrs, so it's ready to accept the knob during final assembly.

After it has been fitted to the board, remove its main nut/lock washer combination and turn the spindle by hand to make sure it's at the fully anticlockwise limit. Then refit the lock washer, making sure that its stop pin goes down into the hole between the moulded '7' and '8' digits. Check that the switch is now 'programmed' for the correct seven positions, simply by clicking it around through them by hand.

With S1 fitted, you can add the four diodes. Don't mix them up! D1 is a low power 1N4148 'signal' diode, D2 is a UF4003 'fast' rectifier, D3 is a 1N4004 1A power diode and ZD1 is a 10V/1W zener. Use the overlay diagram as a guide to their orientation when you're fitting each one to the board.

Next fit transistor Q1, followed by the two 5mm LEDs. The red one is used as LED1 and the green one as LED2. They are both mounted vertically with their leads left at almost full length, so that the lower surface of their bodies is about 23mm above the surface of the board.

This allows them to just protrude through the matching holes in the lid/front panel when the board assembly is attached behind it.

At this stage your board assembly is very close to complete, with the main task remaining being to wind transformer T1 and fit it to the board. You'll find the full details on how to do this in the separate panel.

Once the transformer has been fitted to the board, you can attach the four 25mm M3 tapped spacers to it as well. These each attach very close to each corner of the board, using 6mm long M3 screws passing up from the underside.

Now all that remains to complete the board assembly is to plug IC1 and IC2 into their sockets. Place it aside while you prepare the case to receive it.

## Preparing the case

There are no holes to be drilled in the lower part of the case (the battery holder can be held securely in place using strips of 'industrial' double-sided adhesive foam tape) but the lid does need to have holes drilled for the various switches, LEDs and input/output connectors.

The location and dimensions of all these holes are shown in the diagram of Fig.5, which is actual size so it (or a photocopy) can also be used as a drilling template. The larger holes are easily made by drilling them all first with a 7mm twist drill and then carefully enlarging them to size using a tapered reamer.

We have prepared an artwork for the front panel if you would like to make it look neat and professional. This can be either photocopied (Fig.6) or downloaded as a PDF file from our website and then printed out.

Either way the resulting copy can either be covered with self-adhesive clear film or, better still, laminated, for protection against finger grease, etc before it is glued to the lid/panel.

Mount switches S2, S3 and S4 on the panel, followed by the binding posts used as the meter's test terminals and the banana sockets used for the output connections to your DMM.

Tighten the binding post and banana socket mounting nuts firmly, to make sure that they cannot come loose with use. Then use the second nut of each post and socket to attach a 4mm solder lug plus a 4mm lockwasher to make sure they don't work loose either.

Now you can turn the lid assembly over and solder 'extension wires' to the connection lugs of the three switches, and also the solder lugs fitted to the rear of the binding posts and sockets. These wires should all be about 30mm long and cut from tinned copper wire (about 0.7mm diameter).

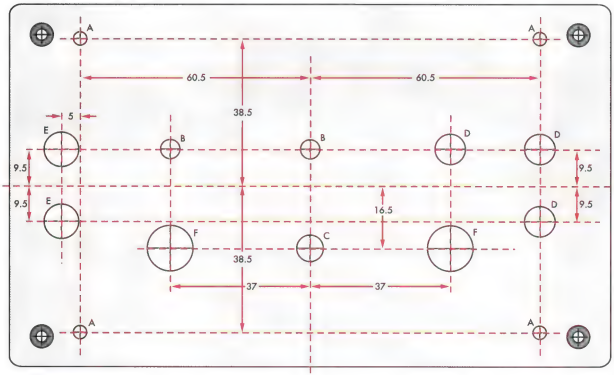



**Fig.5: a 1:1 drilling template for the front panel of the specified jiffy box.**

## Parts List – Capacitor Leakage DMM Adaptor

1 PC board, code 04204101, 145 x 84mm
1 UB1 jiffy box, 158 x 95 x 53mm
1 Single pole rotary switch, PC mounting (S1)
2 SPST mini pushbutton switch (S2, S4)
1 SPDT mini toggle switch, panel mounting (S3)
1 Mini DIL reed relay, SPST with 5V coil (RLY1)
2 Premium binding posts, 1 x red and 1 x black
2 4mm banana jack sockets, 1 x red and 1 x black
1 16mm diameter fluted instrument knob
1 Ferrite pot core pair, 26mm OD
1 Bobbin to suit pot core
1 3m length of 0.5mm diameter enamelled copper wire
1 25mm M3 Nylon screw and nut and two flat washers
2 8-pin DIL IC sockets
4 1mm dia. PC board terminal pins
4 25mm long M3 tapped spacers
8 6mm long M3 machine screws, pan head
1 10x AA battery holder (flat, side by side)

**Semiconductors**

1 MC34063 DC/DC converter controller (IC1)
1 LM358 dual op amp (IC2)
1 BC327 PNP switching transistor (Q1)
1 10V 1W zener diode (ZD1)
1 5mm red LED (LED1)
1 5mm green LED (LED2)
1 1N4148 100mA diode (D1)
1 UF4003 fast 1A diode (D2)
1 1N4004 1A diode (D3)

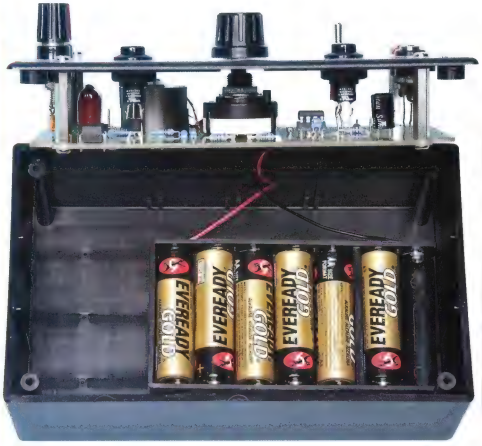
**Capacitors**

1 470µF 16V PC electrolytic
1 100µF 16V low leakage electro
1 2.2µF 250V (or 100V) metallised polyester
1 100nF multilayer monolithic ceramic
1 820pF disc ceramic

**Resistors** (0.25W 1% unless specified)

| | | |
|---|---|---|
| 1 1MΩ | 1 270kΩ | 1 68kΩ |
| 1 36kΩ | 1 33kΩ | 1 22kΩ |
| 2 10kΩ | 1 8.2kΩ | 1 5.1kΩ |
| 1 3.6kΩ | 2 2.4kΩ | 1 2.2kΩ |
| 1 2.0kΩ | 2 1kΩ | 2 470Ω |
| 1 270Ω | 1 200Ω | 1 150Ω |
| 2 100Ω | | |

1 1.0Ω 0.5W carbon (5%)




**"Opened out" view showing the PC board "hanging" from the front panel.**

The next step is to prepare the battery holder. Because you can't buy a six-way flat AA holder (at least we couldn't find one!) we cut down a ten-way AA holder.

The last three cell positions are removed altogether (at the 'negative lead' end) and then the eyelets are drilled out and used to attach the contact spring for the sixth cell position and also the contact spring and negative lead connection lug at the end of the removed section.

This will allow you to re-attach the negative lead's connection lug to the contact spring for the sixth cell using a 6mm long M2 machine screw and nut. The seventh cell position is still retained to support the sixth cell connection spring and the negative lead connection lug.

The converted battery holder can now be fitted inside the main section of the box at lower right, with the connection lead side uppermost. Mount it using double-sided adhesive foam as mentioned earlier, or simply a strip of 'gaffer' tape.

You should now be ready for the only slightly fiddly part of the assembly operation: attaching the PC board assembly to the rear of the lid/front panel.

This is only fiddly because you have to line up all of the extension wires from switches S2, S3 and S4, the two test terminals and the output banana sockets with their matching holes in the PC board, as you bring the lid and board together. At the same time you have to line up the spindle of switch S1 and the two LEDs with their matching holes in the front panel.

This is actually easier to do than it sounds, so just take your time and the lid will soon be resting on the tops of the board mounting spacers. Then you can secure the two together using four 6mm long machine screws.

Now it's simply a matter of turning the complete assembly over and soldering each of the switch and terminal extension wires to their board pads. Once they are all soldered you can clip off the excess wires with sidecutters.

If you find this description a bit confusing, refer to the assembly diagram in Fig.4. This will hopefully make everything clear.

Next solder the bared end of the red (positive) battery holder lead to the positive battery terminal pin at the upper right on the PC board, and the

## Resistor Colour Codes

| | No. | Value | 4-Band Code (1%) | 5-Band Code (1%) |
|---|---|---|---|---|
| ❑ | 1 | 1MΩ | brown black green brown | brown black black yellow brown |
| ❑ | 1 | 270kΩ | red violet yellow brown | red violet black orange brown |
| ❑ | 1 | 68kΩ | blue grey orange brown | blue grey black red brown |
| ❑ | 1 | 36kΩ | orange blue orange brown | orange blue black red brown |
| ❑ | 1 | 33kΩ | orange orange orange brown | orange orange black red brown |
| ❑ | 1 | 22kΩ | red red orange brown | red red black red brown |
| ❑ | 2 | 10kΩ | brown black orange brown | brown black black red brown |
| ❑ | 1 | 8.2kΩ | grey red red brown | grey red black brown brown |
| ❑ | 1 | 5.1kΩ | green brown red brown | green brown black brown brown |
| ❑ | 1 | 3.6kΩ | orange blue red brown | orange blue black brown brown |
| ❑ | 2 | 2.4kΩ | red yellow red brown | red yellow black brown brown |
| ❑ | 1 | 2.2kΩ | red red red brown | red red black brown brown |
| ❑ | 1 | 2.0kΩ | red black red brown | red black black brown brown |
| ❑ | 2 | 1kΩ | brown black red brown | brown black black brown brown |
| ❑ | 2 | 470Ω | yellow violet brown brown | yellow violet black black brown |
| ❑ | 1 | 270Ω | red violet brown brown | red violet black black brown |
| ❑ | 1 | 200Ω | red black brown brown | red black black black brown |
| ❑ | 1 | 150Ω | brown green brown brown | brown green black black brown |
| ❑ | 2 | 100Ω | brown black brown brown | brown black black black brown |
| ❑ | 1 | 1.0Ω (0.5W) | brown black gold gold (5%) | |

black (negative) battery holder lead to the negative pin alongside.

You can now fit six AA-size alkaline cells into the battery holder (make sure you fit them with the correct polarity) and your new Capacitor Leakage Adaptor should be ready for its initial checkout.

### Initial checkout

You'll need to use a twin test lead to connect the Adaptor's output to the input jacks of your DMM. The DMM should also be set to measure DC voltage, and to its 0-1V or 0-2V range if it's not auto ranging.

Switch on the Adaptor's power using S3 and green LED2 should light – showing that the Adaptor is operating, in standby mode and in the default 10mA current range. Then if you press S4, the range change button, LED2 should go dark. This shows that the range switching circuitry is operating. But your DMM should still be giving a zero reading. At this point you can stop pressing S4.

Next try pressing test button S2. This should cause red LED1 to glow, indicating that power is now being applied to the test voltage generation circuitry. If there is no capacitor or other component connected across the test terminals, your DMM should still be giving a reading of zero.

Assuming all has gone well at this point, your Adaptor is probably working correctly.

However if you want to make sure, try shorting the two test terminals. Then set S1 to the '100V' position, and press Test button S2. The DMM reading should change to a value corresponding to 9.9mA (i.e., 990mV), representing the current drawn from the nominal 100V source by the 10kΩ current limiting resistor and the 100Ω current shunt resistor inside the Adaptor.

Don't worry if the current reading is a bit above or below the 9.9mA figure, by the way. As long as it's between about 9.2mA (920mV) and 10.6mA (1.06V), things are OK.

With the terminals still shorted together, you can try repeating the same test for each of the other six test voltage positions of switch S1.

You should get a reading on the DMM corresponding to approximately 6.25mA (625mV) on the 63V range, 4.95mA (495mV) on the 50V range, 3.46mA (346mV) on the 35V range, 2.48mA (248mV) on the 25V range, 1.58mA (158mV) on the 16V range and 990uA (99mV) on the 10V range.

If the readings you get are close to these, your Capacitor Leakage Adaptor is working correctly.

This being the case, switch off the power again via S3 and then complete the final assembly by lowering the lid/PC board assembly into the case and securing the two together using the four small self-tapping screws supplied. Make sure you also remove the shorting wire between the test terminals.

### Using it

The Capacitor Leakage Adaptor is very easy to use, because all you have to do is connect the capacitor you want to test across the test terminals (with the correct polarity in the case of solid tantalums and electrolytics), after connecting the Adaptor's output sockets to the input jacks of your DMM.

Then turn on the DMM and set it to measure DC volts.

Now set the Adaptor's selector switch S1 for the correct test voltage and turn on the power (S3), whereupon LED2 should light. Then to begin the actual test, press and hold down Test button S2.

What you may see first on the DMM is a reading of the capacitor's charging current, which can be as much as 9.9mA (with high value caps) but will then drop back as charging continues. How quickly it drops back will depend on the capacitor's value.

With capacitors below about 4.7μF, the charging may be so fast that the first reading will often be less than 100μA (10mV).

If the capacitor you're testing is of the type having a 'no leakage' dielectric (such as metallised polyester, glass, ceramic or polystyrene), the current should quickly drop down to less than 10μA (1mV).

## Winding autotransformer T1

The step-up autotransformer T1 has 60 turns of wire in all, wound in four 15-turn layers. And as you can see from the assembly diagram at right, all four layers are wound on a small Nylon bobbin using easily handled 0.5mm diameter enamelled copper wire. Use this diagram to help you wind the transformer correctly.

Here's the procedure: first wind on 15 turns, which you'll find will neatly take up the width of the bobbin providing you wind them closely and evenly. Then to hold them down, cover this first layer with a 9mm-wide strip of plastic insulating tape or 'gaffer' tape.

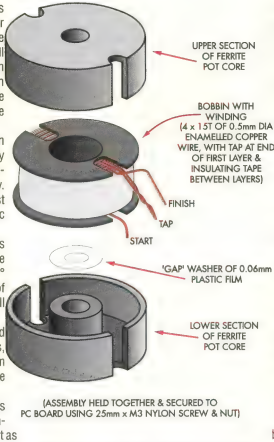
Next take the wire at the end of this first layer outside of the bobbin (via one of the 'slots') and bend it around by 180° at a point about 50mm from the end of the last turn. This doubled-up lead will be the transformer's 'tap' connection.

The remaining wire can then be used to wind the three further 15-turn layers, making sure that you wind them in the same direction as you wound the first layer.

Each of these three further layers should be covered with another 9mm-wide strip of plastic insulating tape just as you did with the first layer, so that when all four layers have been wound and covered everything will be nicely held in place.

The 'finish' end of the wire can then be brought out of the bobbin via one of the slots (on the same side as the start and tap leads) and your wound transformer bobbin should be ready to fit inside the two halves of the ferrite pot core.

Just before you fit the bobbin inside the bottom half of the pot core, though, there's a small plastic washer to prepare.




This is to provide a thin magnetic 'gap' in the pot core when it's assembled, to prevent the pot core from saturating when it's operating.

The washer is very easy to cut from a piece of the thin clear plastic that's used for packaging electronic components, like resistors and capacitors.

This plastic is very close to 0.06mm thick, which is just what we need here. So the idea is to punch a 3-4mm diameter hole in a piece of this plastic using a leather punch or similar, and then use a small pair of scissors to cut around the hole in a circle, with a diameter of 10mm. Your 'gap' washer will then be ready to place inside the lower half of the pot core, over the centre hole.

Once the gap washer is in position, you can lower the wound bobbin into the pot core around it, and then fit the top half of the pot core. The transformer is now be ready for mounting on the main PC board.

First place a Nylon flat washer on the 25mm-long M3 Nylon screw that will be used to hold it down on the board. Then pass the screw down through the centre hole in the pot core halves, holding them (and the bobbin with gap washer inside) together with your fingers.

Then lower the complete assembly down in the upper left of the board with the 'leads' towards the right, using the bottom end of the centre Nylon screw to locate it in the correct position. When you are aware that the end of the screw has passed through the hole in the PC board, keep holding it all together but up-end everything so you can apply the second M3 Nylon flat washer and M3 nut to the end of the screw, tightening the nut so that the pot core is not only held together but also secured to the PC board.

Once this has been done, all that remains as far as the transformer is concerned is to cut the start, tap and finish leads to a suitable length, scrape the enamel off their ends so they can be tinned and then pass the ends down through their matching holes in the board so they can be soldered to the appropriate pads.

Don't forget to scrape, tin and solder BOTH wires which form the 'tap' lead – if they are not connected together, the transformer won't produce any output.

And if you press button S4 on the Adaptor to switch down to the 100µA range, you should be able to see the DMM reading fall down to zero.

That's if the capacitor is not faulty, of course.

On the other hand if the capacitor is one with a tantalum or aluminium oxide dielectric with inevitable leakage, the current reading will drop more slowly as you keep holding down the Test button.

In fact it will probably take up to a minute to stabilise at a reasonably steady value in the case of a solid tantalum capacitor and as long as three minutes in the case of an aluminium electrolytic.

(That's because these capacitors generally take a few minutes to 'reform' and reach their rated capacitance level.)

As you can see from the guide table earlier the leakage currents for tantalum and aluminium electrolytics also never drop down to zero but instead to a level of somewhere between about 4.1mA and 1µA depending on both their capacitance value and their rated working voltage.

So with these capacitors, you should hold down the Adaptor's test button to see if the leakage current reading drops down to the 'acceptable' level as shown in the guide table and preferably even lower.

If this happens the capacitor can be judged 'OK' but if the current never drops to anywhere near this level it should definitely be replaced.

What about low leakage (LL) electrolytics? Well, the current levels shown in the guide table are basically those for standard electrolytics rather than for those rated as low leakage.

So when you're testing one which is rated as low leakage, you'll need to make sure that its leakage current drops well below the maximum values shown

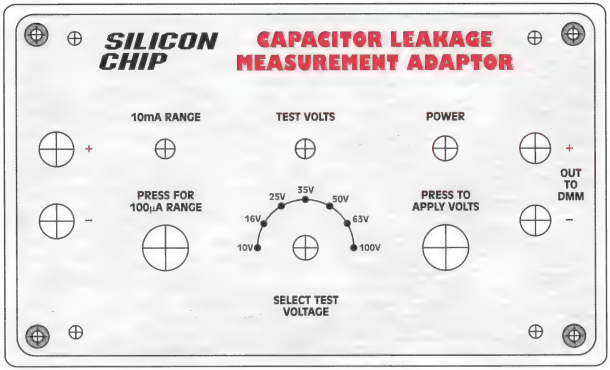
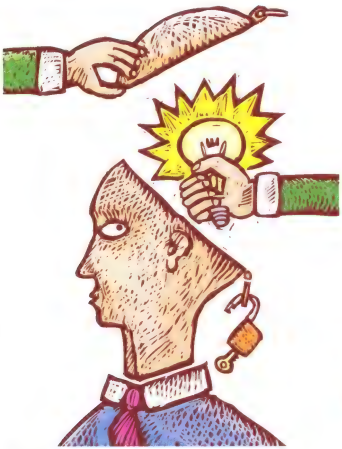



**Fig.6: same-size front panel artwork.**

in the guide table. Ideally it should drop down to no more than about 25% of these current values.

A final tip: when you're testing non-polarised (NP) or 'bipolar' electrolytics, these should be tested twice – once connected to the terminals one way around and then again connected with the opposite polarity.

That's because these capacitors are essentially two polarised types, internally connected in series, back-to-back. If one of the dielectric layers is leaky but the other is OK, this will only show up in one of the two tests. SC

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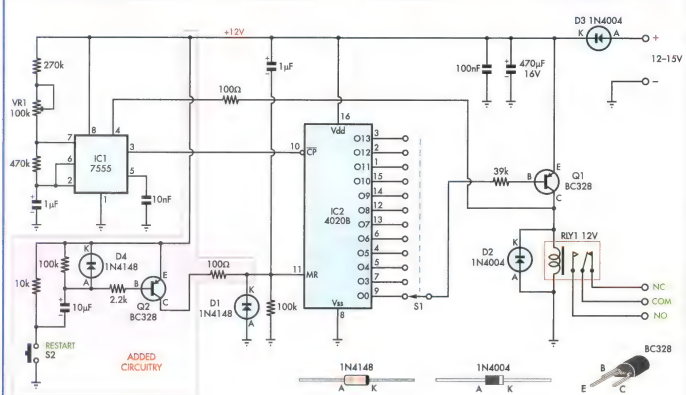
# CIRCUIT NOTEBOOK

**Interesting circuit ideas which we have checked but not built and tested. Contributions from readers are welcome and will be paid for at standard rates.**




## Adding a restart to the modified Flexitimer

The modified Flexitimer circuit featured in the Circuit Notebook pages of the April 2009 issue was designed to start timing at power up and then stop after the timeout period. To repeat the cycle, the power would be switched off and on again to reset counter IC2.

This add-on circuit, highlighted in pink, allows timing to be started with a pushbutton switch.

When power is first applied to the whole circuit, the 10µF capacitor associated with switch S2 is discharged and transistor Q2 is off. This allows the reset at pin 11 of IC2 to be initially pulled high at power up via a 1µF capacitor to the 12V rail. This resets IC2 and allows the timing cycle to start.

After timeout, the circuit is quiescent until switch S2 is pressed. This pulls the negative side of the 10µF capacitor low and transistor Q2 is biased on via current through the 2.2kΩ resistor. Q2 then pulls pin 11 of IC2 high, resetting it so that the timing cycle can restart. Q2 then switches off when the 10µF capacitor charges to 12V.

When S2 is released, the negative side of the capacitor is pulled high via the 10kΩ resistor and the positive side of the charged capacitor is clamped by diode D4 to the +12V supply rail. This discharges the capacitor, ready for another restart.

**John Clarke,**
**Silicon Chip.**

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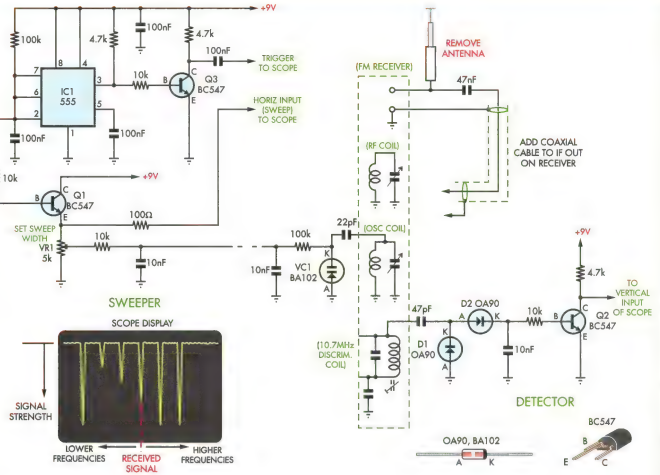



## Simple panoramic adaptor for a communications receiver

Many communications receivers have an interesting and seldom-used socket on the back, labelled IF OUTPUT, VIDEO or similar. This is an output from the first mixer stage of the radio before it goes through any filtering. It is is broadly centred on the first IF (intermediate frequency) of the radio, usually around 70MHz.

If the receiver is tuned to say 7.5MHz, a band of adjacent frequencies will be available at this socket, shifted up by 70MHz , typically from 77-78MHz.

### Panoramic adaptor

A panoramic adaptor is simply a second tunable IF that sweeps up and down from the centre frequency by ±500kHz and its output can be displayed on an oscilloscope that is synchronised with the sweep signal. The display is very similar to that from a spectrum analyser.

This simple panoramic adaptor involves an FM radio which has its tuning range (normally 88-108MHz) lowered to bracket the IF of the communications receiver. This is best achieved by placing small ferrite cores into the air-spaced windings. Modify the oscillator coil first, to arrive at the correct frequency with the tuning capacitor at around half scale. Then modify the RF coil to maximise gain.

Next, add the varicap diode and the other few components to the FM tuner's oscillator coil, using very short leads. Remove the telescopic whip antenna and add a coax socket to provide the connection to the IF output of your communications receiver.

### AM detector

A simple AM detector involving two OA90 diodes is then added across the discriminator coil of the FM radio. Adjust this coil for maximum signal strength.

The circuit involving IC1, a 555 timer configured as a sawtooth oscillator running at around 100Hz, provides the sweep control voltage for the varicap in the FM tuner, as well as horizontal and trigger signals for the oscilloscope. If your scope does not have an external Horizontal or Sweep input, the trigger pulse from Q3 can be used to synchronise the scope's internal timebase.

### Using it

In use, the tuned station will always peak in the centre of the screen, with adjacent frequencies to either side. It looks quite impressive but is an indication of band occupancy only.

Note also that the peaks of the display will be upside down. This can be fixed by adding an inverting buffer on the detector output.

**Dayle Edwards,**
**Westland, NZ. ($60)**

## Blackout alarm for a life-support machine

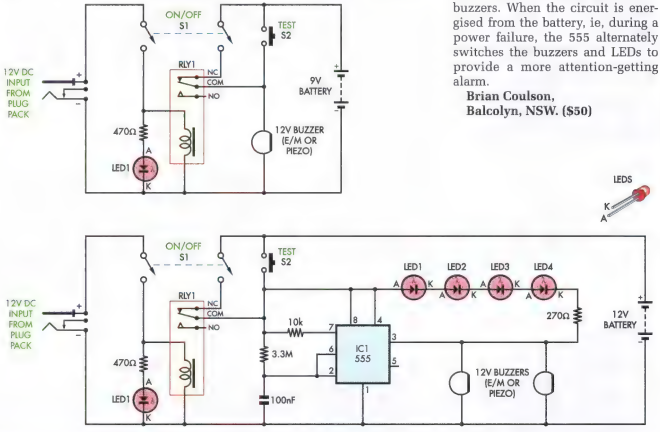
These two circuits were devised to provide a loud alarm in case of a failure in the power to a life-support machine.

The first circuit is based on a relay which is always energised from a 12V DC plugpack for as long as the mains supply is present. In this condition, LED1 is alight and the 12V buzzer is out of circuit. When the power fails, the relay is de-energised and its NC (normally closed) contact feeds power to the buzzer from a separate 9V battery.

Pushbutton switch S2 provides a test facility to check the buzzer and battery.

The second circuit uses the same relay system but in this case, the NC contacts feed power from a separate 12V battery to a 555 timer circuit (IC1) which drives one or two 12V buzzers. When the circuit is energised from the battery, ie, during a power failure, the 555 alternately switches the buzzers and LEDs to provide a more attention-getting alarm.

**Brian Coulson,**
**Balcolyn, NSW. ($50)**

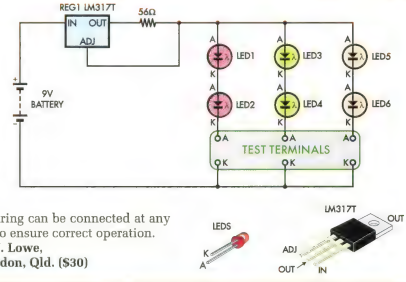


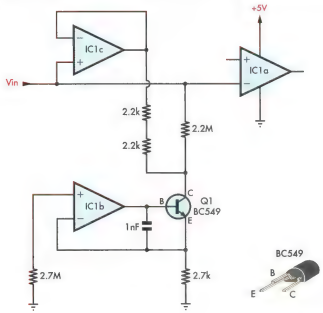

## Constant current source LED sorter

This simple circuit can be used to compare and sort LEDs for brightness. It uses an LM317T with its out connected back to the ADJ terminal via a 56Ω resistor. The LM317 maintains its fixed reference voltage of 1.25V (nominal) across the 56Ω resistor and thereby converts the voltage regulator to a current regulator, providing about 22mA to the LEDs.

You can wire this to a Protoboard or a fixed jig with various coloured LEDs to provide a basis for comparison. Note that while three LED strings are shown in the circuit, only one string can be connected at any time to ensure correct operation.

**A. J. Lowe,**
**Bardon, Qld. ($30)**






## Cancelling op amp input bias current

Op amp input bias currents are an important consideration in the design of low-drift peak detectors and sample-and-hold circuits, designs involving high impedances and circuits requiring precision when dealing with very small voltages, such as the output of a thermocouple.

Modern JFET-input op amps have extremely low input bias currents but varieties that operate from low-voltage single supplies, like the 5V supplies used by digital logic, are expensive. An alternative approach when working with low-voltage supplies is to use a bipolar device such as an LM324 and compensate for the input bias current.

Most bipolar op amps use PNP input stages, so their inputs behave as current sources as far as the input bias current is concerned. This unwanted current can be cancelled out by connecting the input pin to a current sink configured to sink the same current that the input pin is sourcing.

The data sheets of many dual and quad bipolar op amp packages show how to do this, by making the necessary current sink from a second op amp in the same package (so that it will have similar characteristics to the device being compensated) and a bipolar transistor. The input bias current of the non-inverting input of the second op amp is used to set the sink current.

Unfortunately, the bipolar transistor used in these designs has to be a special type that has a high beta at the very small currents involved. The circuit presented here sidesteps this problem by sinking a large multiple of the input bias current. This brings the current up to a level where an inexpensive transistor can be used in the current sink. The circuit then divides this current so that just the right amount is sourced by the input pin that needs input bias current compensation, while the remainder is sourced through the output of a third op amp from the same package.

### Circuit details

In the circuit, IC1a is the op amp with an input that is to be bias current compensated while IC1b and transistor Q1 form the current sink. IC1c is connected as a voltage follower to source the balance of the current.

The input bias current of the non-inverting input of IC1b is converted to a voltage by the 2.7MΩ resistor connected from that input to ground. Negative feedback makes the voltage across the 2.7kΩ resistor the same as the voltage across the 2.7MΩ resistor. This results in a current at the collector of Q1 equal to 1000 times the input bias current of the non-inverting input of IC1b.

One thousandth of this sink current, equivalent to the input bias current of the non-inverting input of IC1b, is sourced from the input of IC1a (the input having its input bias current compensated). Another thousandth of the sink current is sourced by the non-inverting input of IC1c and the remaining 998 thousandths of the sink current is sourced from the output and inverting input of IC1c.

This split is performed by the two series 2.2kΩ resistors and the 2.2MΩ resistor. The top end of the two series 2.2kΩ resistors is held at the same potential as the top end of the 2.2MΩ resistor by the output of voltage follower IC1c. The current through the 2.2MΩ resistor will therefore be two thousandths of the current in the 2.2kΩ resistors.

The minimum input voltage for the compensation to work is determined by the sum of the voltages across the 2.2MΩ resistor, $V_{CE(sat)}$ of Q1 and the voltage across the 2.7kΩ resistor.

For the component values shown, if $I_{B(max)}$ is the worst case input bias current in amps, the minimum input voltage is $7.1 \times 10^6 \times I_{B(max)} + 0.1V$. For an LM324 at 25°C, $I_{B(max)}$ = 150nA and the minimum input voltage is therefore 1.17V.

Having such a high minimum input voltage requirement is not as problematic as it might seem, since single-supply applications generally offset signals above the 0V level anyway, first to be able to handle negative signals and second, because the output impedance of single supply op amps increases significantly for outputs close to 0V.

It is nevertheless possible to reduce the minimum input voltage required by reducing the values of the resistors in the circuit. However, the accuracy of the compensation will be reduced as the voltage across the 2.2MΩ resistor becomes smaller relative to the input offset error voltage of IC1c and also as the voltage across the 2.7kΩ resistor becomes smaller relative to the input offset error voltage of IC1b.

**Andrew Partridge,**
**Toowoomba East, Qld.**

Andrew Partridge is this month's winner of a Peak Atlas Test Instrument

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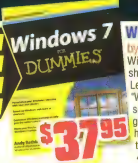


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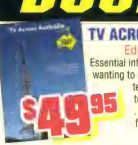


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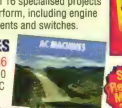


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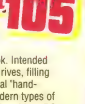


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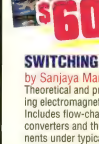


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# SERVICEMAN'S LOG

## Those lazy, hazy days of air-conditioning

**A bloke needs his air-conditioning, especially during Sydney's recent hot, humid weather. Unfortunately, that's when it's also the most likely to break down and inflict pain and suffering on a hard-working serviceman.**

With the hot humid weather upon us, there is nothing worse than a faulty air-conditioner – especially when you are low on funds after the Christmas thingy.

In this case, the impecunious victim was yours truly. I had bought a cheap 2HP Danair reverse-cycle split-level air-conditioner from Aldi in 2005 for $600. It then cost me another $600 to have it installed by a licensed refrigeration technician/installer, so it cost me just $1200 all up

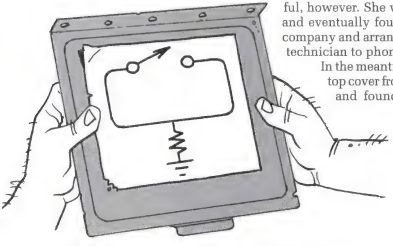
At the time, I thought I had done pretty well and it hadn't missed a beat in five years until, of course, the compressor warranty ran out. The fault started out as being intermittent but it finally just would not cool or heat at all. All the fans were working and you could hear the compressor apparently trying to start for a brief period before giving up.

Initially, I thought it might be dust on the evaporator core and filters and so, sexist beast that I am, I got the missus to give it a good going over with the vacuum cleaner. When that proved fruitless I checked to see if the thermostat was damaged. It looked OK to me but then I'm an amateur when it comes to air-conditioning (I'm much more expert on catching computer viruses).

Next, I checked the outside unit and found that the two cooling pipes were not changing temperature so perhaps I had lost the gas. I then looked inside the box but to the uninitiated everything looked sweet – no signs of stress, smoke or broken parts.

I got onto Google and tried to track down an authorised Danair service agent but without success. I was on the edge of cutting my losses and getting a new one but being mid-summer the queue to buy and install air-conditioners was around the block. Mrs Serviceman was more successful, however. She went through Aldi and eventually found a local service company and arranged for the service technician to phone us back.

In the meantime, I removed the top cover from the outside unit and found a wiring/circuit diagram glued to the inside of the lid. This showed that the circuit was in fact very simple, with a 50µF 450V starter capacitor in series with the compressor. Similarly, there was a 3µF 450V capacitor in series with the fan motor. The fan seemed to be running perfectly but it was always possible that something wasn't quite right and it was setting off a safety circuit that turned the compressor off.



THIS SHOWED THAT THE CIRCUIT WAS IN FACT VERY SIMPLE

The service company technician eventually phoned back and I had a chat with him. He was friendly enough and told me that these were excellent units. He also told me that it was highly likely that it was the capacitor that was at fault, as the compressor hardly ever failed.

The cost of a new compressor is $470 plus fitting, while the capacitor comes in at $50. As a result, I ordered one from WES Components. Well, I actually ordered two capacitors – a 40µF 400V capacitor and a 10µF 400V capacitor, as they did not have a single 50µF 450V unit in stock. They cost less than $50 delivered.

When they arrived, I connected them in parallel in place of the old capacitor and switched the power on. Eureka! – it all worked perfectly. I then checked the old one on my capacitance meter and found that it dropped its value from 50µF to just 8.25µF.

I was a bit worried about reducing the working voltage of the capacitors to only 400V but we are not talking 3-phase here – besides which 450V units weren't readily available at such

### Items Covered This Month

- Danair reverse cycle split level air-conditioner
- How to catch a computer virus
- Sanyo C20PE70-00 (A7-A20 chassis)
- Hairong ATX-320WB computer power supply

a cheap price. If they fail, I'll know what to do.

## Gullible me

Much to Mrs Serviceman's concern, I buy far too much stuff on eBay from all over the world. The vast majority of this is promptly delivered but occasionally you get the odd one which takes the economy scenic route and arrives very late.

After one such mass purchase, I got an email purporting to be from DHL. It basically said that the company was unable to deliver my parcel due to an address error but that I could pick it up personally. All I had to do was print out the accompanying attached label and take it with me.

Now this is one of the oldest scams in the book but I really was expecting a parcel and I was tired, and I wasn't thinking and my brain was well and truly out of gear (all of the above excuses and more). Gullible me clicked the attachment open just as Mrs Serviceman screamed "Don't"!

Her warning came too late and my computer was immediately infected with malware. My anti-virus program then rushed to my aid and told me the bleeding obvious, namely that I was infected. From that point, my computer was virtually unusable. I tried installing a number of other virus/malware cleaners but the computer had clammed up.

As I later discovered, the attachment, DHL_label_Nr8735.zip, unzipped into IS15.exe, qKmfGb.exe, winlogon32.exe, and smss32.exe and plonked these onto my computer's hard drive, mainly in the c:\windows\system32 folder.

The real problem when you have done something this stupid is to know what to do next. Perhaps the best course of action is to power down immediately while you suss out the problem using Google on another computer. In my case though, I did the worst thing possible and got onto the web (where all these leeches hang out) and tried getting onto the Symantec website to download and use a specific virus killer but they didn't have one.

I then tried "Googling" IS15.exe and of course came up with lots of hits – but which would you trust? Many are in direct cahoots with spyware like this and might just open the door wider.

After reading a few of the sites, the consensus was to delete the main offending files in the system32 folder – if you can. If you can't, you have to reboot in Safe Mode and try again.

By using the Microsoft System Configuration Utility (msconfig.exe), you can place the computer in the Diagnostic Mode which means you can prevent the unwanted malware from starting when the computer boots. I could actually see some of these malware files in the Startup list, so I unticked them. I could also have set the System Restore program to an earlier time before the attack. However, I did the opposite and turned it off, preventing the invader from reinstalling itself through the back door.

I was lucky, as I was able to eventually delete these files so I could then install and run SpyBot Search and Destroy v1.6.2. This was done to completely clear the hard drive of all the other nasties that came through with the original hit. I then reset the Startup menus to boot correctly and re-enabled System Restore.

Fortunately, the machine had not suffered any lasting damage and everything is now back to normal. I will be

a lot more careful with these emails in future. In fact, I won't be touching them with a barge pole.

If only I'd listened to Mrs Serviceman for once in my life.

## Baby boomer technology

Because we are located in an area heavily populated with baby boomers and older folk, we find that many people are reluctant to get rid of their old dinosaur CRT TVs. The excuse often is that the buttons on the remotes of the older units are bigger and the sets are simple to use. However, when they fail, the cost of repairing one of these old bangers can quickly approach the cost of a new LCD set!

Faye just could not be convinced that her old Sanyo C20PE70-00 (A7-A20 chassis) wasn't worth repairing and she insisted that I take it to the workshop and make it well again. Now we haven't seen a 51cm black plastic-cased CRT TV in here for quite a few years, so I had a real sense of deja vu (what ever that means).

Its fault symptom was that it was dead, with just its red front-panel LED flashing. However, this set was made before the advent of error codes so the degree of flashing was irrelevant. I initially thought that fixing this piece of ancient technology would be a piece of cake but my arrogance was to be short-lived.

I started by checking for shorts on the line output stage. I found none so I checked for shorts on each supply rail in turn and they were all OK too. I then switched the set on and checked the +130V rail. This proved to be a bit high and I then remembered that the resistors around this model's +130V control often gave trouble, causing the set to close down due to excessive B+ and EHT.

However, everything checked out OK in this case and the control could easily be adjusted. I also established that the low-voltage supply rails were OK as well, the only exception being the 24V rail which the remote control switches on from standby. This is controlled by the CPU and powers up the horizontal drive stage.

This rail is also tied up with the protection circuits, so I figured this was probably a good area to investigate. After wasting a lot of time, I eventually concluded that the protection circuits were OK but the CPU was unable to switch transistors Q713, Q715, Q552 and Q551 on. However, when I applied 0.6V from an external source to switch these transistors on (by using the internal battery of my analog ohmmeter), I could switch the set on and produce sound and a good picture.

So why wasn't it switching on via the CPU (IC701), which I was now beginning to suspect? However, a quick check with my scope revealed that the CPU was in fact trying to switch the start-up circuit.

While I was pondering what the hell was going on, I thought I would do a little housework. C562, a 22µF 200V capacitor on the +160V (B3) rail to the video output transistors, was domed at one end – a sure sign that it had dried out. It was obviously still functioning to some extent, although the rail was down slightly.

Replacing this capacitor restored the full 160V and I then noticed C563 (330µF 35V) which is right next to it. If one electro had dried out, then it was highly likely that the one adjacent would also be crook. The circuit shows C563 as being across a 24V rail to Q551. I measured this and it was down to just 15V.

Replacing this electro restored the +24V rail and what's more, the set now switched on and off perfectly without any flashing red LEDs.

Ironically, now that I come to think of it, I'm sure that I have fixed this model before for the same reasons. However, my memory on these old sets has long since faded.

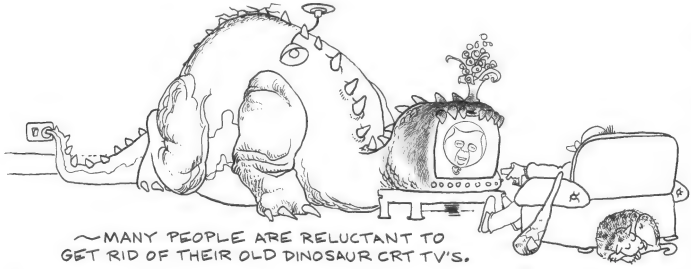
My next items comes from A. P. of Toowoomba East, Qld. Here's how he tells it . . .

## The Phantom CPU Killer

My friend Maree is a single mother trying hard to make ends meet and I have helped her with her generic Windows XP Home computer once before, when it started to run very slowly. On that occasion, I deleted all the unnecessary doodads from the system tray and the start-up folder and upgraded the RAM to 1GB.

Recently, Maree called me again, saying her computer had become unreliable and that it had crashed on several occasions. Now it was just showing "No signal" on the monitor.

My first thought was that the crashing was most likely a software problem and the lack of a video display could be



# Philips Radioplayer 124 Valve Radio –Addenda

Last month, I described how I repaired a 1950 Philips Radioplayer 124 valve radio. This had a potentially lethal trap because the speaker frame was found to be operating at high-voltage, due to the fact that the laminations of the speaker transformer were connected to the B+ (or HT) line.

A reader has since pointed out that the transformer laminations were connected to B+ in order to prevent breakdown to the transformer core. However, the transformer was normally potted in a bituminous compound, so that it was electrically isolated from its case (and thus from the loudspeaker frame).

In the unit that I serviced, there has apparently been a breakdown between the transformer core and its aluminium housing, which is why the loudspeaker frame was at high voltage. You've really got to watch yourself with these old radios.

just a loose cable. I asked Maree about the connection to the monitor and when that seemed to be good, I asked her whether she could hear if the fans were running in the system unit (yes, they were). I then had her press and hold the power switch for about five seconds and she reported that the fans stopped.

I had her power it up again and listen carefully, first for any signs of hard drive activity and second, for any beeping sounds. She wasn't sure about the hard drive and I don't blame her, as modern hard drives are usually very quiet and difficult to hear above the fan noise. As for the beeping, she told me that there was normally a single beep when it started up but now there was no beep at all.

Even though the start-up beep was absent, I then had Maree press the sequence <CTRL>+<ESC\>UU (this is a keyboard shortcut that will shut down Windows if the desktop is showing) and tell me if the fan noise stopped. It didn't, so I asked her to bring me the system unit but not the monitor.

When she arrived with the computer I took the sides off the tower and immediately noticed that it was choked with dust, particularly around the CPU heatsink. There was a faint burnt smell coming from the power supply fan but it was more the smell of cooked dust than the smell of a component that had met its maker.

I vacuumed it all out as best I could, then plugged in the power cable, keyboard, mouse and monitor and verified that the symptoms were exactly as Maree had described over the phone. There was nothing for it but for her to leave it with me.

Shortly after Maree left, I pulled out the memory DIMMs, cleaned the contacts, and re-inserted them. Bingo! The computer started up with no problems but was it really going to be that easy?

I normally like to make sure that things really are fixed before returning them but I knew that Maree needed the computer the next day. And since she was probably only half-way home I quickly called her. She

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## Servicing Stories Wanted

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We pay for all contributions published but please note that your material must be original. Send your contribution by email to:

editor@siliconchip.com.au

and be sure to include your full name and address details.


returned, thanked me and took the computer away.

All things considered, I wasn't terribly surprised when Maree phoned the next morning to say that the computer had stopped again after working for only about one hour.

This time, when she returned the computer, I decided to isolate the problem properly. I removed the memory DIMMs from the motherboard, and unplugged both the power and data connectors from the drives. With just the monitor, power supply and power switch connected to the motherboard, I powered it up but was greeted with the same symptoms of fans running but no video display and no beeping. I then measured the +5V and +12V supply rails at one of the spare disk connectors. Both rails were within tolerance and showed a very low ripple reading when I switched my DMM to the AC volts range.

At this point, I suspected that the build-up of dust on the processor's heatsink had reduced its cooling efficiency to the point where the processor had been damaged by overheating. The lack of any beeps during power-up certainly pointed in that direction.

Fortunately, I had a spare ABIT NF7-S motherboard complete with an AMD Athlon XP 2800+ processor and cooler in my stock and this seemed to be the quickest and easiest way to get the computer going again. Of course, I would have to re-install Windows XP Home and find suitable drivers for everything but I suspected that the computer was about due for a Windows reinstallation anyway, even if I had managed to rescue the existing motherboard and processor.

Having replaced the motherboard, I connected the power supply, the power switch and the CPU fan to it and then got ready to test it out. However, when I went to plug in the monitor, a small problem surfaced – I had forgotten that the ABIT motherboard did not have onboard video. I rummaged in my stock and found an NVidia Quadro NVS 280 PCI Dual Display Card that I had previously tested with the NF7-S motherboard.

Because I was using a known good motherboard and video card, I expected success when I first turned the computer back on but it wasn't to be. The fans ran but as before, there was no beep and no video. Perplexed, I checked the power supply rails again but they were within tolerance and stable.

In short, I could find no reason for the new motherboard not to work and eventually concluded that either it or the processor had developed a fault.

Plan B was to replace the processor in the original motherboard. It was an Intel Celeron 2.6GHz CPU 478 pin and I found one on eBay with the same specification number (SL6W5) as the original for just $17 (including delivery). When it arrived, I fitted it and was delighted at the result: the video was now working and Windows XP Home booted successfully.

But had I really fixed the problem? I left the computer running and just 10 minutes later there was a glitch on the screen and when I went to move the mouse I found that the computer had frozen. I powered it off by pressing and holding the power button for five seconds, then turned it back on to be greeted by fans but no beep and no video.

Now I was really baffled. Did we have a faulty motherboard or was there an intermittent fault in the power supply? I gave up at this point and found an Optima system unit on eBay with similar specifications. It came with a 2.6GHz Intel Celeron processor, 512MB RAM, a 40GB hard drive, DVD ROM and Windows XP Home, all for the princely sum of $54.00. I bought it and upgraded it to 1GB RAM and an 80GB hard drive by swapping over the parts from Maree's existing system.

Having solved the problem as far as Maree was concerned, I still needed to satisfy my curiosity: was the problem with her original computer somehow caused by the power supply? It was a Hairong ATX-320WB and when I removed the cover and vacuumed out the dust, the problem was immediately obvious: all the electrolytic filter capacitors in the high-frequency section were bulging. I tested the ESR of one of them and it measured 2Ω.

As a further test, I turned on the power supply and measured all the rails. They all had very low ripple and were in tolerance but when I connected an 8Ω dummy load to the +3.3V rail, the ripple on all the rails (not just the +3.3V rail) shot up to 0.5V RMS at 30kHz! This is probably because this power supply unit only regulates the +3.3V rail, so any ripple on that rail becomes superimposed on the other rails.

That explains why I had not detected the power supply fault: it had destroyed each new processor at switch-on, meaning they weren't drawing anything from the 3.3V rail by the time I took my measurements. We live and learn – in future, I won't exonerate a computer's power supply without first testing it on a simple resistive dummy load. SC

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- 2 speed belt drive turntable
- 33 1/3 and 45 RPM
- Anti-skating control
- Motor off and reverse function
- RCA Phono/line output
- Dimensions : 449(W) x 145(H) x 370(D) x mm

AA-0494

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## Solar Powered/Dynamo Robot Kit

Build your own solar powered robot. Also supplied with a hand cranked dynamo for alternative power source. Robot moves forward and reverses. Hours of robotic fun.

- No batteries needed
- Recommended for ages 8+

KJ-8821

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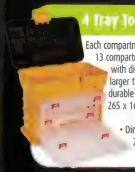
## 4 Tray Tool / Storage Case



Each compartment has a 233 x 122 x 32mm 13 compartment storage box for small items with dividers that can be removed to accommodate larger things. All the hinges and catches are the durable pintle type and the top tray has a generous 265 x 160 x 65mm space for ancillary items.

- Dimensions: 270(W) x 260(H) x 150(D)mm

HB-6302

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- Individually switched
- Surge and overload protected
- 4 or 6 way

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Cat. MS-4064

$19.95

6 Way Surge/Overload Protected Powerboard
Cat. MS-4066

$24.95

## Low Capacitance Adaptor for DMM Kit

Refer: Silicon Chip Magazine March 2010

$34.95

Many modern multimeters come with capacitance ranges, but they're no good for very small values. This kit is a nifty little adaptor that allows a standard digital multimeter to measure very low values of capacitance from less than one picofarad to over 10nF. It will allow you to measure tiny capacitors or stray capacitances in switches, connectors and wiring. The kit is complete with PCB, components and case. All you'll need is a 9V battery & just about any modern DMM.

KC-5493

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## All-in-One Card Reader with 6 slots & USB Hub

As well as being able to read a multitude of formats, it also has a flip open top to store a number of micro, SD or XD cards. There is also a two port USB 2.0 hub. The USB cable neatly tucks into the back when not in use.

- Ideal for roving photographers
- Dimensions: 87(L) x 39(W) x 18(H)mm

XC-4924

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## 5W Single Channel Amplifier

Sometimes you don't need gigawatts and multi channels. A versatile small audio amp for the workshop, test lab or as a small PA or busking amp. RCA and microphone inputs, dual speaker outputs. 12VDC or mains powered. Please note that this amp is mono.

- Power output: 5WRMS
- THD: 0.5%
- S/N ratio: 79dB
- Short circuit and thermal protection
- Dimensions: 190(L) x 170(W) x 85(H)mm

AA-0473

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## USB 3.0 Has Arrived!

USB 3.0 is here and offers data rates of up to 4.8Gbps - a quantum improvement over USB 2.0. Two leads available:

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Cat. WC-7770 $15.95
Plug A to Plug B Lead - 1.8m
Cat. WC-7772 $15.95

## NEW TOOLS

### Stainless Cutter / Pliers Set

Set of five 115mm cutters and pliers for electronics, hobbies, beading Etc. Stainless steel with soft ergonomic grips.

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Contents:
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- Long nose pliers
- Flat nose pliers
- Bent nose pliers
- Round nose pliers

TH-1812

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Ideal for on-site repairs and PCB work. Heats to soldering temperature in about 10 seconds. Requires 3 x AA batteries.

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## LED Laboratory Magnifier Lamp

Clearly see what you're working on with this multifunctional laboratory magnifier. Included is an extension pole that transforms it from a desk top unit into a floor standing unit, also included is a detachable desk-mounting clamp. Can be powered with the provided plug pack or 4 x C size batteries which allows this unit to be used where mains is not available.

- 20 high-brightness LEDs
- 4 dioptre magnification
- 127mm diameter lens
- 1200mm floor mode height
- 600mm desk mode height
- Mains plugpack included
- Base measures: 310(L) x 230(W)mm

QM-3542

**$99.00**

Also available Desktop LED Magnifying Lamp Cat. QM-3544 $49.95

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## Interlocking Relay Socket with Leads

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The easy way to add multiple relays to an electrical system. These relay bases interlock together and take standard 4 pin automotive relays. They also come with integral flying leads so termination is easy.

•Leads 150mm long

SY-4078

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## IP66 Industrial ABS Enclosures

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Gasket seals, stainless steel hardware and IP66 rated for use in industrial, marine and other harsh environments. The closures have a locking catch that engages to positively hold the lid closed until disengaged. Each enclosure includes a 1.8mm galvanised chassis for mounting DIN rail, switchgear, relays or circuit breakers. A size for any application.

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**Opaque cover:**

Small 125(L) x 125(W) x 75(D)mm — Cat. HB-6400 **$16.95**

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- Adjustable compression depth

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- Autoranging
- Continuity test
- Display: 6000 count
- CAT III 600V
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## Fixed Jaw Clampmeter

The ideal test instrument for electrical contractors. Compact and light with probe storage in the back for easy one-handed operation. Jaw opening is 16mm.

- Non-contact voltage sensor
- Data hold
- Auto power-off
- Diode test
- Audible continuity test
- Category: Cat IV 600V, Cat III 1000V
- Display: 2000 count
- Dimensions: 190(H) x 62(W) x 42(D)mm

QM-1567 WAS $179

**$149**

SAVE $30

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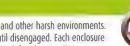
## Pencil Butane Torch

Pocket sized gas torch for heatshrinking, soldering etc and uses standard butane gas. Adjustable flame, all metal construction.



Size: 205(L) x 13(Dia)mm

TS-1667

**$11.95**

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## Rare Earth Magnets

Super powerful with 4.5mm countersunk mounting holes. Two sizes available:

**Round**

25(Dia) x 5mm

Cat. LM-1626

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50(L) x 25(W) x 5(H)mm

Cat. LM-1628

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## 12V 3A Timer Module 2 Seconds to 10 minutes

The start and stop functions are controlled by simple switch inputs and the relay output can control a device of up to 3A.

- Operating voltage: 12V
- Current consumption: 20mA
- Time adjustment: 30 sec to 10 min
- Dimensions: 60(L) x 45(W) x 20(H)mm

AA-0364

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## TOOL SETS

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### 92 Piece 12V Rotary Tool Set

Drill, saw, sand, polish, carve or grind in your workshop or out on the road. 90+ bits and attachments cover every possible task you'll ever need. The rotary tool is rated for 12V at 12,000 RPM. Ideal for hobby or professional use. See website for full list of attachments.

**$29.95**

- Case size: 240(L) x 200(W) x 70(D)mm

TD-2451

### Micro Drill Bit Set 0.7 - 2.2mm

Every hobby engineer needs a set of micro drill bits in the workshop. Quality HSS in incremental sizes from 0.7 to 2.2mm.

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- Sizes: 0.7mm, 0.8mm, 0.9mm, 1.0mm, 1.2mm, 1.4mm, 1.6mm, 1.8mm, 2.0mm, 2.2mm.

TD-2407

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Attention cable & digital TV installers!

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- Compression crimp tool
- Heavy duty cable cutter
- 10 x F-59 plugs
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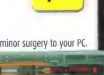
**Torx Key Set:** T5, T6, T7, T8, T9, T10, T15, T20, T25

Cat. TD-2170 $7.95



**Ball Allen Key Set Metric:**

1.5, 2, 2.5, 3, 4, 5, 6

Cat. TD-2172 $7.95

**Ball Allen Key Set Imperial:**

1/16", 5/64", 3/32", 1/8", 5/32", 3/16", 7/32"

Cat. TD-2174 $7.95

**$7.95ea**

### Computer Tool Kit

All the essentials for doing some minor surgery to your PC. Don't forget your anti-static strap.

Kit contents:

- Driver bit handle
- Bits: Slotted 3mm, 4mm, PH 0, 1, T10, T15
- Hex adaptors: 4mm, 5mm
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TD-2150

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SLA battery charger for automotive, marine, motorcycle, workshop or industrial use. All feature switchmode operation, multi-stage maintenance and charging, near-bulletproof performance and microprocessor control. IP rated for use in workshops & hostile environments.

- Short circuit and reverse polarity protection
- Anti-spark protection

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## Deluxe Mains Power Meter

In addition to telling you the cost of electricity consumption of an appliance plugged into it and the amount of power used in kilowatt hours, it will state how many cumulative kg of $CO_2$ the appliance is putting into the atmosphere. Battery included.

- Dimensions: 120(L) x 58(W) x 40(H)mm

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## Wireless 3 Outlet Mains Controller

Simply plug in any mains appliance rated up to 10A and use the remote to turn each one on or off individually, or control all of them together. One of the outlets also has an LED night light that's also operated with the remote. Not just for couch potatoes, it also has real benefits for the elderly or disabled.

- 433MHz
- Remote battery included
- Remote measures: 125(W) x 45(H) x 17(D)mm

MS-6142

$44.95

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## 24 -12V DC-DC Converter

DC to DC converters are useful for running 12V devices from a 24V supply in a truck or bus. These have switchmode technology for light weight and compact design and are rated for 10A. Input and output is via cigarette lighter plug and socket.

- Input voltage: 20 - 30VDC
- Output voltage: 13.8VDC
- Max. output current: 10A
- Continuous output current: 7A
- Efficiency: 85%
- Dimensions: 160(L) x 48(W) x 48(H)mm

MP-3352

$69.95

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## Home Theatre Powerboard

Surge protection and filtering is provided to all your home theatre equipment connected to this powerboard as well as current protection via the in-built circuit breaker.

- Provides protection to telephone, data via a network connection, satellite/cable TV and TV aerials.

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## High Quality Banana Piggyback Test Leads

A set of factory-moulded piggy-back style banana plugs, each connected by one metre of high-quality 500VDC 12A rated cable. The set contains 2 x black, 2 x red and 1 each of blue, yellow and green leads - 7 in all.

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## LED LIGHTING

### LED Torch Kit

Configure the light in any of three different ways: a hand-held torch, headlamp or a handy lantern. The head torch comes with its own battery pack and head band and the lantern makes the ideal tent light for camping. Lanyard and tripod included.

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- Output 120lm • Torch 98(L)mm

ST-3391

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### LED Night Light with Sensor

No need to stub your toe when you get up in the middle of the night. Keep one of these plugged in and it will give you enough light to see where you're going. Operates automatically.

- Rotates through 360° to light any direction
- Automatically comes on in darkness
- Unobtrusive size - smaller than a double adaptor

ST-3181

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## IP67 Rated Illuminated Pushbutton Switches

IP67 rated for industrial use or other harsh environments. Illuminated, metal body, SPDT, on-off or momentary action. Rated for 250VAC @ 3A, with 12VDC LED illumination. Mounting hole 16mm.

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| Red SPDT | Cat. SP-0791 $17.50 |
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FROM $14.50

new

## DPDT Illuminated IP65 Rated Pushbutton Switches

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| | |
|---|---|
| Red DPDT Momentary | Cat. SP-0741 $9.95 |
| Red DPDT | Cat. SP-0745 $12.95 |
| Green DPDT Momentary | Cat. SP-0747 $9.95 |
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## 2.4GHz Dipole MIMO Antenna 7dBi

Suitable for Wireless N routers to improve signal strength and data throughput. Higher end wireless N routers make use of 3 antennas to maximise the amount of bandwidth the unit can send and receive. 3 antennas that can be moved 120° around their axis or rotated 90° so they are perfectly horizontal.

- Working Frequency Range: 2400 - 2500 MHz
- Magnetic base

AR-3280

**$49.95**

## Long Range Bluetooth Dongle

Long range wireless connectivity. Convert your PC to Bluetooth quickly and easily. Communicate with phones, PDAs, headsets and other devices.

Fast data transfer, V1.1, V1.2 and V2.0 compliant, class 1.

- Range: up to 100m
- Transfer rate: 3Mbps
- Operating system: Windows 98, ME, 2000, XP

XC-4896 WAS $29.95

**$24.95**

SAVE $5

## Micro USB Digital Tuner

Coupled with a laptop, you can enjoy your favourite HDTV programs from practically anywhere with this USB DVB-T Pico TV stick. Plug into a PC system and tune into your favourite programs with the included software.

- Free-to-air Digital TV (DVB-T)
- Supports Time-shifting allowing you to pause live TV
- Supports scheduled recording
- USB 2.0 interface
- Supports High Definition Digital TV (HDTV)
- Includes mini MCX DVB-T aerial & remote control

XC-4897

**$89.95**

## Clip-On Notebook Speakers

With a unique slimline design, these clip-on notebook speakers are ideal for travelling. They're USB powered and connect via standard 3.5mm audio out jacks. Used either clipped onto your laptop screen or freestanding.

- Win 2000/XP/ Vista compatible
- Dimensions: 45(W) x 75(H) x 25(D)mm

XC-5193

**$39.95**

## Wireless USB Trackball Remote Control for PC

The trackball works as a mouse and you can type numbers or text in the same way you do with a mobile phone. It also has quick-launch keys, plus controls for multimedia use - play, pause, record etc. You can also program macros or single commands into any key. No software or drivers are needed - just plug in the USB receiver and off you go. Requires 2 x AA batteries.

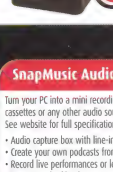
- 2.4GHz 10 metre range
- 19mm optical trackball & mouse keys
- USB dongle receiver
- Microsoft Windows XP MCE/ Vista compatible
- MCE hot keys
- Dimensions: 180(L) x 50(W) x 30(H)mm

XC-4940

**$89**

## 360W 750VA Line-Interactive UPS

Protect your valuable computer system and critical data from black-outs, brown-outs, and power surges. In a worst-case scenario, even if you perform regular backups you could lose irreplaceable data in a blink-of-the-lights. However with an uninterruptible power supply (UPS) installed, it will constantly monitor the mains supply and in the event of a power interruption it switches your system to battery power and enables it to be shut down without data loss. Supplied with a 7Ah SLA battery for 3 minute back-up time at full load, RS232 interface cable and software. See website for full specs.



- Dimensions: 382(L) x 124(W) x 225(H)mm

MP-5201

**$129**

Also available: 900W 1500VA Line-Interactive UPS Cat. MP-5203 $299.00

## Solar Powered Shed Alarm - Short Form Kit

Refer: Silicon Chip Magazine March 2010

Not just for sheds, but any location where you want to keep undesirables out but don't have access to mains power: a boat on a mooring, for example. What you need is a simple solar powered alarm that works from a variety of sensors - just what this kit does. It has 3 inputs so you can add extra sensors as required, plus all the normal entry/exit delay etc.

Short form kit only - add your own solar panel, SLA battery, sensors and siren. Kit includes PCB and electronic components.

Supply voltage: 12VDC
Current: 3mA during exit delay; 500µA with PIR connected

KC-5494 Note: Box not included

**$29.95**

## LAPTOP ACCESSORIES

### 150W Mains Powered Universal Notebook Power Supply

Designed for the more power-demanding notebook PCs, this power supply has a universal input voltage of 100-240VAC 50-60Hz and has stabilised output, over-voltage, over-current, output short, and over-heating protection. Comes with 16 DC plugs for compatibility with all major brands. Check our website for compatibility with your laptop. Also includes USB port to charge USB devices such as mobile phones, digital cameras, MP3 players, etc.

- Voltage range: 12 - 20V @ 7.5A; 22-24V @ 6.25A
- Dimensions: 171(L) x 68(W) x 39(H)mm

MP-3473

**$129**

### Slimline Notebook Cooling Pads

Prevent common notebook overheating problems with one of our new USB-powered cooling pads. Portable design, energy efficient and whisper quiet operation - simply a must-have notebook accessory.

**Slimline Notebook Cooling Pad** Cat. XC-5214
Size: 218(W) x 188(D) x 22(H)mm

**$13.95**

**Foldout Twin-Fan Notebook Cooling Pad** Cat. XC-5216
Foldout size: 275(W) x 183(D) x 17(H)mm

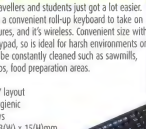
**$9.95**

## Mini Roll-Up Wireless Keyboard

Life for business travellers and students just got a lot easier. Now you can have a convenient roll-up keyboard to take on the road or to lectures, and it's wireless. Convenient size with splash resistant keypad, so is ideal for harsh environments or areas that have to be constantly cleaned such as sawmills, factories, workshops, food preparation areas.

- Standard QWERTY layout
- Washable and hygienic
- Supports Windows
- Size: 370(L) x 123(W) x 15(H)mm

XC-5145 WAS $69.95



**$59.95**

SAVE $10

## SnapMusic Audio Capture for PC

Turn your PC into a mini recording studio. Record and archive music from your old vinyl records, cassettes or any other audio source directly to your PC and save the files as high-quality WAVs or MP3s. See website for full specifications.

- Audio capture box with line-in/out, S/PDIF in/out and mic-in all-in-one
- Create your own podcasts from any program material
- Record live performances or lectures
- Convert audio files formats
- Burn high quality audio CDs
- Includes SnapMusic Studio 715 and Roxy Easy Media Creator 9 LE

XC-4994

**$89**

All Savings are based on Original RRP

**Better, More Technical**

**To order call 1800 022 888**

# Jaycar 2010 Catalogue OUT NOW!

DON'T JUST SIT THERE, BUILD SOMETHING

## In-Dash DVD/MultimediaPlayer with USB & Bluetooth®

A solid all-round performer, this in-car entertainment system plays all the popular multimedia formats and devices. It is Bluetooth® handsfree ready and comes complete with detachable anti-theft panel with colour LCD display and slimline remote control.

- Front USB port, SD/MMC card slot and aux-in
- PLL tuner with 18 x FM and 12 x AM presets
- DVD±R/RW, CD-R/RW playback
- Supports MP3, JPEG and WMA files
- 4 channels x 20WRMS output (40WRMS max)
- 4-band equaliser (classic, pop, rock, flat)

QM-3788

new

$249

## Touchscreen DVD/Multimedia Player

Comprehensive in-car connectivity - this impressive unit plays all the popular AV formats from just about any portable media or mass storage device. Plus it's Bluetooth-ready for handsfree communication when paired with a Bluetooth® enabled mobile phone. It's user-friendly touchscreen menu enables you to easily select and control several input play options. Mounting hardware, Bluetooth® bus and remote control included.

- Motorised 7" touchscreen LCD (480 x 234 pixels)
- 22WRMS x 4 channels (45W max each)
- Front panel USB, SD & aux-in
- 1 x rear camera input, 1 x video output

QM-3789

new

$499

## Car Amplifier Wiring Kits

Complete wiring kits for installing a car amplifier - everything you need down to the cable ties and screws. Save $$ on the individual parts. 4G and 8G kits available.

AA-0442

See our website for kit contents:
**8G Wiring Kit** Cat. AA-0442 $59.95
**4G Wiring Kit** Cat. AA-0444 $99.00

## Twisted Pair RCA Stereo Audio Cables

Featuring RFI and EMI noise reduction to keep your car's audio sounding wholesome. This twisted pair RCA cable is made from double aluminium foil and quality copper braid shielding for that accurate sound transfer.

- Plug to Plug • Split centre pin connectors
- Frosted jacket design
- Platinum-plated ends

5 Lengths:

| | | |
|---|---|---|
| 0.3m | Cat. WA-1079 | $14.95 |
| 0.5m | Cat. WA-1071 | $14.95 |
| 1.5m | Cat. WA-1073 | $19.95 |
| 2.5m | Cat. WA-1075 | $24.95 |
| 5.0m | Cat. WA-1077 | $29.95 |

new

FROM $14.95

## Blade Fuse Current Meter

The quick and easy way to measure current in automotive circuits. Simply slot the adapter into the blade fuse holder and take a current measurement. Adapters for standard, mini and maxi size fuses.

- Peak hold and data hold
- Analogue/3 1/2 digit digital display
- Dimensions: 112(L) x 45(W) x 33(D)mm

QP-2257 WAS $99
Limited stock

$69
SAVE $30

## Remote Control Car MP3 Player

An MP3 player that plugs directly into your cigarette lighter socket. This unit will transmit audio playback from an SD card, USB Flash disk or any external audio source via the auxiliary input to any frequency in the FM band of your car stereo. Controls are performed through the front panel, IR remote of the steering wheel mounted IR remote.

- 2.5 - 3.5mm stereo cable included
- Supports SD/MMC or USB
- Supported audio formats: MP3, WMA
- Measures: 70(H) x 50(W) x 22(D)mm

AR-1865 WAS $59.95

$49.95
SAVE $10

## VIFA

### Vifa Car Speaker Grilles

Car speaker grilles to suit our range of Vifa car speakers, but will suit many other car audio applications. Made from perforated steel, finished in black.

new

FROM $9.95

| | | |
|---|---|---|
| 5" Car Speaker Grille | Pair Cat. AX-3600 | $9.95 |
| 6" Car Speaker Grille | Pair Cat. AX-3602 | $12.95 |
| 6x9" Car Speaker Grille | Pair Cat. AX-3604 | $14.95 |

### Vifa Coaxial Car Speakers

Vifa coaxials will add true high fidelity to your car audio. All feature the legendary Vifa silk dome tweeters, strontium magnets and composite diaphragms. Available in 2 or 4-way configuration. Sold as a pair.

**Vifa 5" 2 Way Car Speakers** Cat. CS-2393 **$99** pr
• Power handling: 60WRMS

**Vifa 6.5" 2 Way Car Speakers** Cat. CS-2395 **$129** pr
• Power handling: 80WRMS

**Vifa 6 x 9" 4 Way Car Speakers** Cat. CS-2397 **$189** pr
• Power handling: 150WRMS

## HID Dual Lamp Conversion Kits

Used in the latest model luxury and high performance cars, High Intensity Discharge (HID) vehicle headlights are far brighter, whiter and more efficient than their quartz halogen predecessors.

35W HID Xenon lamps - H4 base
6000K colour temperature comparable to sunlight
Extra bright 3200 lumens

Available in two easy-installation models:

| | | |
|---|---|---|
| **HID Dual Lamp H4 Conversion Kit - low beam** | Cat. SL-3416 | **$99** |
| **HID Dual Lamp H4 Conversion Kit - high/low beam** | Cat. SL-3417 | **$149** |

new

Warning: State roads & traffic authorities prohibit the retrofitting of these products to cars with normal headlights. Advised to be used only for off-road and showroom vehicles when replacing quartz halogen bulbs, or as headlight replacements for HID factory-fitted new model vehicles.

## HID Single Beam Bulbs

Drop-in replacements for cars that have separate HID bulbs for high and low beam. With 3000 hour lifespan, these can be used in single bulb housings but high beams will not function.

- 35W 70-100V
- 3,000 - 30,000K colour temperature
- 2500-3500 lumens

H3, H4 and H7 types available:

| | | |
|---|---|---|
| **12V H3 HID Bulb Single Beam** | Cat. SL-3411 | **$24.95** |
| **12V H4 HID Bulb Single Beam** | Cat. SL-3412 | **$24.95** |
| **12V H7 HID Bulb Single Beam** | Cat. SL-3413 | **$24.95** |

new

$24.95 ea



All Savings are based on Original RRP

Jaycar Electronics

## Dual Channel AV Sender

Allows you to connect two AV sources to the transmitter, share them around the house, and select either of them from the other room, without the hassle of running wires all over the house. The sender operates in the 2.4GHz band for audio and video signals and at 433MHz for the infrared remote control repeater function. The sender can be connected to any two devices such as your TV, Hi-Fi sound system, video recorder, DVD player, set top box, or cable TV system. A selector button on the receiver allows selection between the two connected devices.

AR-1838

**$69.95**

Additional Receivers with remote extender available separately Cat. AR-1839 $37.95

## Vifa 6.5" Woofer

A brilliant and versatile driver that can be designed to perform to 40Hz or lower. Features include a cast magnesium basket, mineral filled polycone and smooth frequency response. Ideal for bass reflex enclosures of 10 - 30 litres.

**$99**

new

Power handling: 70WRMS
Nominal impedance: 8 ohms
Frequency response: 37Hz - 5kHz
Sensitivity: 88db SPL @ 1W, 1m
CW-2106

## 5-Input Remote HDMI Switcher

Five input HDMI selector routes high definition video and audio signals from the selected input to the HDMI output. It's fully HDCP compliant and comes with an infrared remote control. It has a gain control to compensate for long cable runs and includes a mains adaptor.

- 5 x HDMI inputs
- Fully HDMI and HDCP compliant
- Dimensions: 270(W) x 170(D) x 50(H)mm

AC-1693

**$99.95**

## Component/S-Video to HDMI Upscaler

new

Upscale component or S-video signals to HDMI. Allows you to output to a wide range of resolutions from 480p to 1080p. The unit will accept input from a composite video source, S-video source, 3.5mm audio source and output it to HDMI. LEDs on the front panel indicate the video source is being used and what resolution it is outputting

- Dimensions: 100(W) x 157(D) x 25(H)mm

AC-1627 Limited stock

Also available Component and Digital/Analogue Audio to HDMI Upscaler Cat. AC-1628 $369

**$299**

## Plasma/LCD TV Wall Brackets

Our range of universal LCD and plasma TV brackets will be perfect for most installations.

- Models available to suit LED/LCD/Plasma TVs from 23" - 60"
- Safety lock for security (CW-2822 and CW-2826 only)
- VESA standard compliant
- Solid steel construction
- Mounting hardware and instructions included

Four models available:

CW-2826 **$59.95**
- Suits TVs from 23" - 37" up to 45kg
- Mounts flat or at fixed 5° angle

CW-2822 **$89.95**
- Suitable for TVs from 32" to 60" up to 80kg
- Adjustable tilt to allow +/-15° tilt and will position the TV 80mm from the wall

CW-2828 **$199**
- Suits TVs from 32" to 60" and up to 80kg
- Range of rotation of 90° from the twin 500mm extension arms

CW-2825 **$149**
- Suits TVs from 32" to 60" and up to 80kg
- Gives a range of rotation of 180° and tilt of ±15°
- Ideal for corner mounting

**FROM $59.95**

## HDMI to VGA/Component & LR Analogue Audio Converter

Converts your PC monitor into the main display for a Blu-ray player or gaming console such a as PS3. It will also convert LR analogue audio with a 3.5mm socket for use with most PC speakers and headphones.

new

- Dimensions: 140(W) x 38(H) x 94(D)mm

AC-1605

**$149**

## HDMI LEADS

new

### Wall Plate with HDMI Flyleads

Standard Australian/NZ GPO mount with HDMI sockets for AV installations. Comes with a single or dual HDMI port with flexible flylead for better inner wall clearance.

**Single HDMI Wall Plate Socket**
Cat. PS-0287 **$14.95**
**Double HDMI Wall Plate Socket**
Cat. PS-0289 **$24.95**

### Economy HDMI Leads

These HDMI leads are a cost-effective solution without compromising quality or performance. They all have gold plated connectors and are fully HDMI v1.3b and HDCP compliant.

| | | |
|---|---|---|
| 1.5 metre | WQ-7415 | **$24.95** |
| 3 metre | WQ-7416 | **$34.95** |
| 5 metre | WQ-7417 | **$49.95** |

limited stock

### HDMI Lead with Rotating Plugs 1.5m

HDMI cable with a difference- the plug on each end of the cable rotates through 180° to accommodate whatever installation challenge you have.

**$14.95**

- 1.5m length
- HDMI 1.3 compliant

WQ-7401

## HDMI Cable Tester

Designed to check and troubleshoot the pin connections of Type A HDMI cables quickly and easily. It's ideal for testing the continuity of each signal pin of an HDMI cable prior to installation. Requires 9V battery.

- Carry case included
- Dimensions: 215(L) x 38(W) x 36(H)mm

AA-0406 WAS $149

**$99**

SAVE $50

## PERFECT FOR YOUR HOME THEATRE

### HDMI Over Cat 5 Extender

Boosts your video/audio transmission distance up to 60m (200ft) in HDTV 720p/1080i format. With two low cost Cat 5/5e/6 cables, you can extend HDTV sources from DVD players, Blu-ray Disc player, PS3, PC, and any other HDMI compliant source to distant display monitors, embedded IR receiving and emitting units.

- HDMI 1.3c compliant
- Dimensions: 80(L) x 60(W) x 25(H)mm

AC-1689 WAS $219

**$169**

SAVE $50

### IR Over Cat 5 Extender/Repeater Kit

Control AV source equipment up to a distance of 250 metres away with existing IR remote controls over Cat 5 cable. The IR remote signals are piped down the Cat 5 cable for full control at the remote location. Suitable for home theatre, lecture theatres, AV rooms, conference rooms, shop window and merchandising displays. Extender, repeater, mains plugpack and emitters included.

new

- Input: 1 x IR receiver
- Output: 1 x Cat 5, 5 x IR extender
- Receiver frequency: 20 - 60kHz
- Power supply: 5VDC, 500mA
- Dimensions: 62(L) x 50(W) x 23(H)mm

AR-1826

**$149**

# Jaycar 2010 Catalogue OUT NOW!

DON'T JUST SIT THERE, BUILD SOMETHING

## ALARMS

### Entry Level Car Alarm

An affordable car alarm that features voice feedback on alarm status and operational parameters such open doors etc.

- Electronic black box controller
- Shock sensor, ignition cut out relay
- Speaker siren
- Wiring looms
- Bonnet pin switch
- Car charger for the remote controls
- 2 x code hopping remote control units with a built-in torch!

LA-9003 WAS $119

$99 SAVE $20

### Motorcycle Alarm

Protect your two-wheel investment. Waterproof control unit, siren, and remote controls, triggered by a shock sensor mounted in the control unit. Flashing LED deterrent and panic alarm with 12 month warranty. See website for full specs.

Features:
- Anti burglary
- Anti hijacking
- Car park locator function
- Selectable mute arm/disarm

LA-9020 WAS $69.95

$49.95 SAVE $20

### Mini Personal Alarm

This tiny personal alarm has a loud 100dB (A) siren and is small enough to fit in your purse or around your neck. Batteries included.

- Measures: 40(L) x 25(W) x 16(H)mm

LA-5182 WAS $12.95
Limited Stock

$6.95 SAVE $6

### RFID Access Control Keypad

This low cost RFID unit is designed to control door strikes in home or business installations. It allows access by RFID card, password, or a combination of both. Push button exit & duress output signal. 12VDC powered.

- Read range: 140mm (Max.)
- Operating temperature: -15°C to 55°C
- Housing material: ABS

LA-5124 WAS $79.95

ZZ-8950

RFID Tags to suit: ZZ-8952

| | | |
|---|---|---|
| Key Fob Type | Cat. ZZ-8950 $12.95 | |
| Credit Card Type | Cat. ZZ-8952 $6.95 | |
| Lanyard Type | Cat. ZZ-8953 $4.95 | ZZ-8953 |

$69.95 SAVE $10

### Budget 4 Channel Digital DVR with 4 Cameras

Ideally suited to smaller surveillance installations around the home or office, this DVR system uses MJPEG video compression & can store over 150 hours of video on the installed 250GB hard drive. Recording set-up is simple & various trigger modes can be set across the day including timer recording, motion detection, & manual operation.
The system comes complete with:

- DVR with 250GB HDD, 4 camera inputs, USB port, and 1 x composite video output
- 4 x weather resistant COLOUR day/night cameras
- Plug-in interconnection cables
- Wireless remote control
- Mains adaptor
- User manual

QV-3063 WAS $649

$549 SAVE $100

### 2MP Mini Digital Spy Recorder

The ultimate in discrete portable photo and video recording from business meetings to outdoor sports activities. A 2GB Micro SD can support up to 8GB of memory. Includes case, lanyard, two mounting brackets, software, USB and mains plugpack.

- 2 megapixel camera
- High speed recording and fast response
- Manual and sound activated recording functions
- Supports AVI & JPEG formats
- Rechargeable Li battery lasts for 2 hours of non-stop recording
- Measures 55(H) x 20(W) x 28(D)mm

QC-8001 WAS $199

$149 SAVE $50

### Hands Free Colour Video Door Phone

You can view and talk to visitors at your door before letting them in, or you can sound an alarm to turn away unwanted guests. The CCD camera captures clear images even at night thanks to infrared illumination. You can hook up one additional monitor and camera to make a comprehensive front & back door surveillance system.

- 7" TFT screen
- AV input/output
- Mains powered
- Remote door release output

QC-3615 WAS $449

- Spare doorbell unit for QC-3616 $99

$299 SAVE $150

## PARKING SENSORS

### Reversing Sensor with Dashboard Display

Not only does this excellent reversing sensor alert you to objects or people behind your vehicle, it will also give you an estimated distance to them and indicate their approximate location via the dash-board mounted display.

- Monitor measures: 110(W) x 40(H) x 80(D)mm
- Control box measures: 110(W) x 25(H) x 73(D)mm
- 18.5mm sensor hole drill included

LR-8869 WAS $189

$139 SAVE $50

### Magnetic Parking Sensor with Beeper

When you get within 1m of another car or any other object near your bumper, the alarm will sound to alert you. Simple to install, the sensor is completely concealed under the bumper with no drilling required.

- Fits any vehicle
- Easy installation
- Connects to the reversing lights

LR-8861

$49.95

### Economy 4 Channel H.264 DVR / Camera Kit

Multiplexing DVR system with H.264 compression technology - complete with four IR outdoor CCD cameras, four 20 metre pre-wired camera cables and power supply. Fitted with a 250GB HDD, the DVR delivers quality image reproduction at a touch of a button, plus built-in Ethernet capability that enables the unit to be accessed (with password protection) via the Internet using a standard web browser. The recorder features advanced motion trigger recording, video loss detection, remote network record and USB back-up support. Just add a TV or monitor for a complete surveillance system.

QV-8100

250GB HDD INCLUDED

$799

www.jaycar.com.au

All Savings are based on Original RRP

Jaycar Electronics

## Mini Science Kits

**Mini science projects with a difference. Make crystals, superballs, disgusting slime or be your own detective. All the kits have everything you need and include full instructions. Just add a couple of common household items and away you go. Safe, fun and easy. You can buy each project individually, or buy all together in the Super Science Lab. Suitable for ages 8+.**

### Liquid Crystals Kit
Discover how your unique creation is used every day to preserve water. Surprise all your friends creating fake ice or an invisible gem.

**$9.95**

KJ-8930

### Crystal Forest Kit
Learn all the facts about what makes crystal formations grow. All of the ingredients you need are provided.

**$9.95**

KJ-8931

### Slime Shop Kit
Follow the instructions to make your own disgusting slime creation, controlling the sliminess to be as disgusting as you like.

**$9.95**

KJ-8932

### Super Ball Mould Kit
Learn what makes the process possible. Experiment with cool science like density and gravity. Enough ingredients to make heaps of superballs.

**$9.95**

KJ-8933

### CSI Detective Mini Science Project
Find out what the important characteristics used in analysing fingerprints are. The kit has enough material for multiple experiments.

**$9.95**

KJ-8934

### Super Science Lab
All 5 projects together. Save $5 on the individual kits.

**$29.95**

KJ-8935

Limited Stock

## 25MHz Dual Trace Digital Storage Oscilloscope

Ideal entry-level DSO for the advanced hobby user or technician and is particularly suited to audio work. Full data storage capabilities and USB interface so you can store traces on a flash drive.

- Channels: 2
- Input impedance: 1Mohm
- Bandwidth: 25MHz
- Sampling rate: 500MSa/S
- Max input voltage: 400V P-P, Cat II
- Dimensions: 310(W) x 150(H) x 130(D)mm
- Accessories included : 2 x 10:1 probes, EasyScope software, USB cable

QC-1932

**$599**

Also available
100MHz Dual Trace Digital Storage Oscilloscope Cat. QC-1933 $1,149

## USB Combo Image Scanner with LCD

Convert your cherished old images to digital image format with this versatile and easy-to-use combo scanner. With USB connection, you can connect this to your PC and take high resolution scans of all your photos, slides and negatives to preserve in JPEG or TIF format. It also features a handy memory card slot and LCD so you have the option to preview and transfer all your scans directly to memory card without the need for PC connection.

- Crisp 2.4" LCD preview panel
- SD, XD, MMC, MS, MS-Pro memory card slot
- Windows XP and Vista compatible (32 or 64 bit)
- Power via USB connection
- See our website for technical specs

XC-4893

**$269**

## 3W LED Tactical Torch

Bulletproof machined aluminium construction and O-ring sealed for all the rigours of professional work. The tailcap has a tactical switch.

- Requires 3 x AAA batteries
- Output: 120 lumens
- Size: 148(L) x 34(Dia)mm

SF-3399 WAS $19.95

**$14.95**

SAVE $5

Perfect for your Easter camping trip!

## Jumbo LCD Clock

Jumbo-size 19mm high digits for easy reading. Handy clip with double-sided tape for mounting to the dashboard or fridge, battery included.

- Size: 62(L) x 35(W) x 16(H)mm

XC-0220 WAS $12.95

**$2.95**

SAVE $10

Limited stock

## Bargain of the Month!

### Radio Receiver AM/FM/SW with LCD and Clock

This multi-band pocket radio has digital tuning and has a large backlit LCD. It features full clock functions with an alarm and receives AM, FM and SW. Includes a 3.5mm headphone socket and comes complete with a lanyard for portability.

**$9.95**

SAVE $15

- Power: 4.5VDC mains plugpack or 2 x AA batteries
- Dimensions: 112(H) x 70(W) x 24(D)mm

**Normally $24.95** AR-1741

For a limited time only we have reduced the price of our Radio Receiver AR-1741. Hurry in while stocks last!

## YOUR LOCAL JAYCAR STORE

**Australia Freecall Orders: Ph 1800 022 888**

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| Blacktown | Ph (02) 9678 9669 |
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# PRODUCT SHOWCASE

## Jaycar's HDMI Switch, Digital Signal Finder

Jaycar's high-performance 5-input HDMI switcher caters for the growing number of users with HDMI output devices (projectors, monitors, etc) having to switch between various HDMI inputs, without madly unplugging and replugging leads.

Supporting 12-bit deep colour and full 1080p resolution, the $119 switcher, Cat No AC1693, is fully HDCP-compliant and has a gain control to compensate for long cable runs. It includes an infrared remote control and a 5V/2A mains power supply.

The second item featured here will be a boon to TV antenna installers, whether professional or not. It takes the guesswork out of finding the digital signal. And it's just 80 x 66 x 32mm in size.

To tune a digital TV signal, the Digital TV Signal Finder is simply connected to the antenna and the antenna adjusted for maximum LED indication. That's it!

It includes a 9V battery and power connector. Cat No LT3330, retails for $64.95

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Verbatim's new 320GB and 500GB USB Mobile Hard Drives are their most compact and lightweight 2.5" drives yet. They feature USB Turbo Speed, improving transfer speeds by up to 25% via the USB 2.0 high-speed interface. Palm sized and lightweight, the Mobile Hard Drive weighs only 140 grams and has an ultra-compact size of only 11.5 x 7.6 x 1.2cm making it much smaller than other 2.5" drives on offer.

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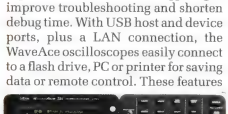
## New LeCroy WaveAces

LeCroy has expanded the popular WaveAce oscilloscope line to include 4-channel models from 60MHz to 300MHz and added a new 2-channel, 40MHz model. The 4-channel models provide 10kpts/ch memory and up to 2GS/s sample rate; the 40MHz model provides 4kpts/ch and a sample rate of up to 500MS/s.

All models offer long memory, colour displays, extensive measurement capabilities and advanced triggering to improve troubleshooting and shorten debug time. With USB host and device ports, plus a LAN connection, the WaveAce oscilloscopes easily connect to a flash drive, PC or printer for saving data or remote control. These features make the WaveAce oscilloscopes the ideal tools for affordable design, debug and troubleshooting from 40MHz to 300MHz.



Available in bandwidths of 60MHz, 100MHz, 200MHz and 300MHz, the new 4-channel models provide a maximum sample rate of 2GS/s and up to 10kpts/ch memory or 20kpts when interleaved. SC

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## New 8-bit low-power PICs from Microchip

Microchip has unveiled several new 8-bit PIC microcontrollers that set the industry benchmark for low power and peripheral integration. Well suited for applications in the appliance, consumer, industrial and automotive markets, they feature active currents of less than 50µA/MHz and sleep currents down to 20nA.

The PIC12F182X MCUs extend Microchip's Enhanced mid-range 8-bit core product line into the 8-pin segment and include mTouch capacitive touch-sensing and communications peripherals.

The PIC16F19XX MCUs also feature a broad range of peripherals, such as an mTouch capacitive touch-sensing module, LCD drive, multiple communications and more Pulse width Modulator (PWM) peripherals.

Microchip's complete suite of standard development tools can also be used with the new MCUs, including the user-friendly and free MPLAB IDE.

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# EHT STICK!

## an Extra High Voltage for Digital Multimeter

***Do you need to measure the EHT voltage in a CRT-based scope, computer monitor or TV receiver, or perhaps in a photocopier, laser printer or microwave oven? You'll need an EHT probe to suit your digital multimeter (DMM) to do this and you'll find they are pretty pricey. Not to worry though, because here's one you can build for less than $40.***

**Measuring really high voltages** is not something you can normally do easily or safely. So if you want to measure the EHT of CRT-based TV receivers or the corona voltages in photocopiers or laser printers, what do you do?

They are up around 22kV or more – far out of the range of a DMM. And if you want to measure the high voltage in a microwave oven – about 3kV or so – that's also way out of range of a DMM.

You can't make this kind of measurement just with a normal multimeter or DMM, because in most cases they have a maximum input voltage rating of 1000VDC or 750VAC.

The only way this type of meter can be used to make measurements on higher voltages is to connect a specially designed EHT divider probe between its input sockets and the source of high voltage. The probe divides down the voltage to be measured by a known factor (usually either 100:1 or 1000:1), to bring it within the voltage range which can be handled safely by the meter itself.

This type of EHT divider probe has

By JIM ROWE

been available commercially for many years, and they're still available if you hunt them down.

They've never been particularly cheap though and if you want to buy a brand-new probe nowadays you'll find they're priced from around $100 and upwards – not easy to justify if you only want to measure EHT voltages every now and again.

## SAFETY WARNING

In order to use EHT divider probes like the one described in this article safely, please note carefully the following points:

1. **The probe's ground return must always be connected** securely to the 'earthy' side of the EHT circuit in which you are making the measurement – BEFORE you connect the probe's measuring tip to the 'hot' side of the circuit. This is most important because if the probe tip is connected first, all of the probe's internal circuitry AND YOUR DMM will be 'floating' at the full EHT voltage and thus represent a very serious safety risk.

2. The probe's ground return lead and its connection clip must be regarded as a vitally important part of the probe itself. It is crucial to achieving correct probe operation, because it provides the only connection between the bottom end of the probe's voltage divider and the EHT circuit in which you are making the measurement.

3. NEVER connect the probe's ground return lead to the 'hot' side of the high voltage circuit, as this will also cause your DMM to be floating at the full EHT voltage. If you need to measure an EHT voltage that happens to be negative with respect to ground, simply reverse the polarity of the probe lead connections to the DMM input jacks. The probe's ground return lead should ALWAYS be connected to the 'cold' or earthy side of the EHT circuit.

4. If at all possible, turn off the power to the EHT circuit before you connect the probe's ground return lead and input measuring tip. Only turn the power back on when both connections are secure and your hands are safely withdrawn. This will help ensure that you don't receive a shock when the probe tip comes into contact with the 'hot' side of the EHT circuit, and also that a 'flashover' arc cannot develop.

5. Turn off the power to the EHT circuit again after you have made the measurement, and before you remove the tip and ground return connections (in that order).

6. If it is not feasible to turn off the power to the EHT circuit before making the probe connections and you have to hold the probe body in your hand while making the measurement, make sure you hold it down at the output lead end. Do not risk a flashover or punch-through by holding it closer to the tip end.

7. **Do not attempt to use this type of probe to make measurements in high voltage power distribution systems.** These can supply a huge amount of energy/power and in most cases cannot be turned off in order to make the probe connections. The risk of serious injury or death is therefore extremely high.

**Test setup using the EHT Stick and a digital multimeter. Always ensure that the green grounding lead is firmly attached to a suitable ground point in the circuit under test BEFORE probing the EHT.**

Our probe, which we've dubbed the "EHT Stick", has been designed to allow you to measure DC voltages up to around 23-25kV, using any standard digital multimeter (DMM) which has an input resistance of 10MΩ. It provides a division ratio of 1000:1, so kilovolts at the input are read simply as volts on the DMM.

Like many commercial EHT probes, it provides an input resistance of just over 800MΩ. So when it's connected across a circuit with a voltage of say 20kV (20,000V), the probe will draw a modest 'loading' current of only 25μA.

In their divider's crucial input leg, commercial EHT probes have always used special very high value 'long spiral' resistors rated to withstand very high voltages but these haven't been readily available for some time.

So instead, we have used 80 (yes, eighty!) high voltage (1.6kV) 10MΩ 0.5W metal film resistors in series to produce the 800MΩ input leg. The Farnell type number for the 10MΩ is 110-0295.

Because of the large number of resistors in series, the voltage drop per resistor is kept well within their maximum voltage rating.

Even when the EHT Stick is measuring a voltage of 25kV for example, the voltage across each resistor in the input leg is only 313V. The power dissipation per resistor will also be less than 10mW.

By the way, don't be tempted to substitute standard 0.25W or 0.5W resistors for the high voltage types specified. Most 0.25W and 0.5W resistors have a voltage rating of only 200-250V or so – certainly not enough!

**Now before we move on to look at the probe's circuit and how it's built and used, please read the text in the safety warning box carefully.**

Making measurements in EHT circuits inevitably presents an increased safety risk, because even in a CRT-based TV set or a microwave oven the EHT circuitry can provide a lethal shock.

So it's important – in fact, vital – that you not only build the probe exactly as we describe and that you follow the correct procedures when making a measurement. If you are careless, the measurement may be the last you ever make!

## Circuit description

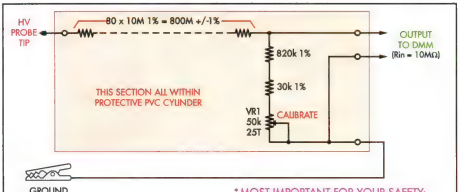
As you can see from the circuit of Fig.1, the probe is just a resistive voltage divider, with an input leg formed by the 80 10MΩ resistors in series.

The lower leg is formed by the 820kΩ and 30kΩ resistors in series with trimpot VR1, with the 10MΩ input resistance of the DMM itself in parallel.

When the value of this composite lower leg is adjusted using VR1 to have a resistance of 1/999 of the input leg (ie, nominally 800MΩ/999, or 800.801kΩ), the divider provides an exact division ratio of 1000:1.

Trimpot VR1 allows you to compensate for the within-tolerance variations in all of the other resistors, to give the probe maximum accuracy.

So while the circuit of the probe is very straightforward, the physical construction presented us with quite




## SC 0201 EHT STICK (1000:1 HIGH VOLTAGE DIVIDER FOR DMMS)

**Fig.1 (above): the circuit is simply a voltage divider giving a suitable output to measure on a digital multimeter.**
**Fig. 2 (right) shows the PC board component overlay. It's not difficult to build but it is quite tedious fitting and soldering 82 half-watt resistors. Note: do not substitute other resistors as their voltage rating may be insufficient.**

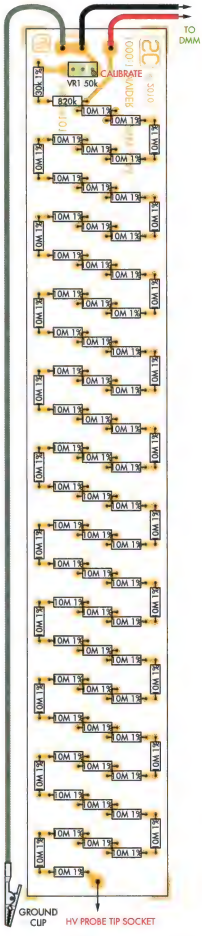
a challenge, in order to meet the somewhat conflicting needs of fitting no fewer than 82 0.5W resistors plus a trimpot into a case that would be compact enough to be hand-held, yet provide a suitably high level of electrical isolation and safety.

### Construction

The approach we came up with was to fit all of the resistors and the trimpot onto a long narrow PC board, measuring 228 x 37mm and coded 04104101. The 80 resistors in the divider's input leg are laid out in a long 'zig-zag' pattern over most of the board's length, to provide the necessary spacing in a reasonably compact area.

The PC board, sleeved in 30mm heatshrink tubing, is designed to fit inside a 250mm length of 43mm OD/39mm ID PVC-U conduit, with a 43mm ID PVC pipe cap at each end to complete the safety isolation.

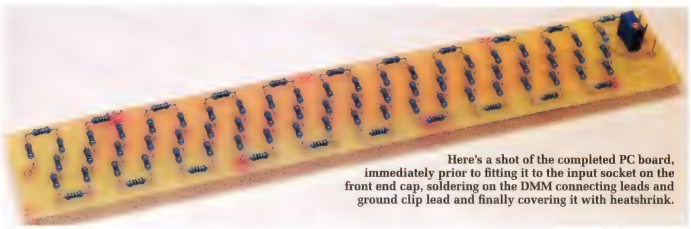
The PVC-U conduit (the -U standing for unplasticised) is type DWV (stands for drain, waste & vent) and it and the matching end caps are made by companies such as Vinidex and Iplex. The conduit and the end caps can be obtained from hardware stores and plumbing supply outlets. Most will supply minimum lengths of 1 metre – a bit of a waste, if you'll pardon the pun – but our 1m length only cost us a couple of dollars. One of these days




### Parts List – EHT Stick

1 PC board, code 04104101, 228 x 37mm
1 250mm length of 43mm OD/39mm ID PVC-U DWV conduit
2 43mm ID PVC pipe cap to suit conduit
1 230mm length of 30mm diameter heatshrink
1 4mm banana socket, red with matching double-adaptor banana plug
1 3.5-6mm cable gland
2 1.2m long 600V-rated test leads (one red, one black) with shrouded banana plugs
1 1m length of mains-rated flexible earth lead, with green insulation
1 32mm (medium) alligator clip, with black or green insulating shroud
4 1mm diameter PC board terminal pins
1 Nylon cable tie, 4mm wide
1 short (~50mm) length brass rod, around 2-3mm diameter (for tip)

**Resistors** (0.5W metal film high voltage – Farnell MH25 series)
80 10MΩ (1.6kV rating – Farnell 110-0295) 1 820kΩ 1 30kΩ
1 50kΩ 25-turn vertical trimpot (VR1)



**Here's a shot of the completed PC board, immediately prior to fitting it to the input socket on the front end cap, soldering on the DMM connecting leads and ground clip lead and finally covering it with heatshrink.**

we're sure to come up with a use for the rest!

Or you might also try your friendly local plumber for an offcut. The plumber might also be good for a short length of 4mm brass rod (eg, brazing rod) to fashion a probe tip from.

The end caps are a (tight!) friction fit onto the conduit. This provides adequate physical security while maintaining good electrical isolation. We suggest you *don't* try to check the fit out before final assembly, because once on, they're not easy to get off again!

A 4mm banana socket is mounted in the centre of one end cap to provide the probe's 'hot' input, the idea being that whichever probe tip (or very short clip lead) you use plugs into the socket via a standard 4mm banana plug.

As we mentioned earlier, a short length of brass rod makes an excellent probe tip – we made ours from a piece of brazing rod about 50mm long (certainly not critical) with a point filed one end and soldered to a banana plug to mate with the banana socket.

A cable gland is mounted in the centre of the other end cap to provide an exit for the probe's output leads and its ground return input lead.

Wiring up the probe board is not difficult but is a little tedious because of the large number of resistors to be fitted. The easiest part is fitting the four PC board terminal pins used to make the off-board connections – one at the input end to mate with the solder lug at the rear of the banana socket, and the other three at the output end to provide the cable connections.

Note that the single pin at the input end should be fitted from the copper side, with its 'top end' cut off flush when you have soldered it to the pad underneath.

Once the pins have been fitted, you can proceed with installing the fixed resistors. They're fitted in the standard way, with the leads bent down at 90° quite close to the resistor body so that when they pass through the board holes, the resistor is lying flat on the top of the board.

The leads are then soldered carefully to the pads underneath, with just enough solder used to produce a nicely rounded joint. The excess leads are then cut off with sharp side cutters as close as possible to the joints, so that no sharp wire ends or 'points' are left.

This is quite important, because any sharp points on conductors carrying high voltage tend to concentrate the surrounding electric field and cause ionisation of the air – producing a 'corona' discharge.

The only other thing to watch when you're fitting the resistors is to fit the 820kΩ and 30kΩ resistors down at the output end of the board, as shown in the overlay diagram.

You might want to fit these first, to make sure they're in the correct positions. Then you can fit the remaining 80 resistors, happy in the knowledge that they are all of the same value.

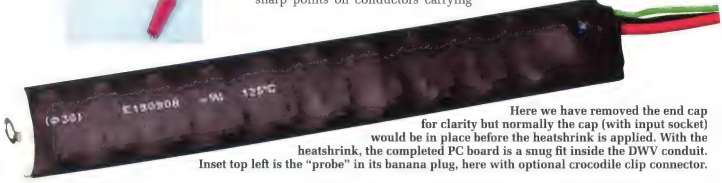
With all of the fixed resistors installed, the only remaining step is to fit trimpot VR1 and your probe's PC board assembly will be complete. It can then be put aside while you prepare the probe's tube and end caps and assemble the whole thing.

## Final assembly

Final assembly also involves calibration. This could be done now that the PC board is complete but it's better to wait until the unit is partly assembled (and therefore partly insulated) as it involves high voltages.

First cut your length of 43mm OD PVC-U DWV conduit to 250mm long. If necessary, square off each end with a flat file, using it to remove any burrs as well.

Next, drill the holes in the centre of



**Here we have removed the end cap for clarity but normally the cap (with input socket) would be in place before the heatshrink is applied. With the heatshrink, the completed PC board is a snug fit inside the DWV conduit. Inset top left is the "probe" in its banana plug, here with optional crocodile clip connector.**

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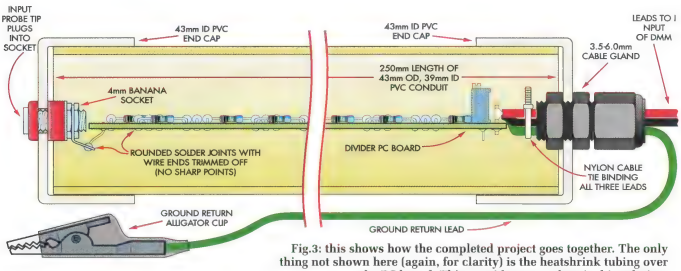


**Fig.3: this shows how the completed project goes together. The only thing not shown here (again, for clarity) is the heatshrink tubing over the PC board. This provides extra electrical insulation.**

each end cap to receive the 'hot input' banana socket and the output cable gland. These both need round holes of around 9mm diameter but the exact diameter will depend on the particular components you use – and the holes shouldn't be any larger than is necessary to receive them.

So it's probably best to drill a ~5mm hole in each cap first and then use a tapered reamer to enlarge it carefully until the socket or gland will just pass through. Then remove any burrs as before.

Mount the input banana socket securely in its end cap, using one of the two nuts supplied to fasten it in position. Next, fit the solder lug and the second nut, tightening this up so that the lug is securely attached to the back of the socket. Then bend the lug over against the side of the second nut. This will bring it into position where its end hole will be as near as possible to the input terminal pin on the end of the divider probe's PC board, when assembled. The bent lug will also help to hold the nut in position.

Now slide the PC board into the end cap so that the solder lug on the banana socket and the PC board input pin can mate. This is a little tricky but if you keep the solder lug and PC board parallel to each other, you should have success.

Once the pin does pass through the hole in the solder lug, you can solder the two together carefully to make the connection permanent.

Make sure that you apply enough solder to form a strong and nicely rounded joint – also take care not to burn the side of the PVC end cap with the barrel of the soldering iron.

Your end cap and PC board assembly should now look very much like the photo below right.

## Putting it together

Loosely fit the cable gland to the other end cap and pass the bare ends of the three exterior wires (ie, the two leads which go to the DMM and the ground lead) through the gland from outside to inside. Pull these three wires through as far as they will go so that the DMM plugs and ground clip lead are against the cable gland.

If necessary, cut the 30mm diameter heatshrink to length (~230mm, give or take) and either cut or drill a pot access hole. We placed a scrap of timber inside the heatshrink and drilled a 6mm hole, right in the centre and 10mm down from the end.

Pass the three external wires right


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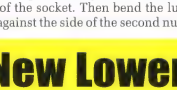

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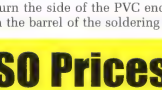

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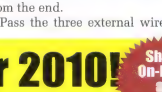

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through the heatshrink, from the pot access-hole end, all the way along the wires (you want to keep the heatshrink away from the heat of soldering in the next step).

Similarly, pass the three external wires through the PVC-U pipe and slide the pipe up the wire. Don't push the end cap onto the pipe, at least not yet!

Now solder the three external wires to their appropriate positions on the PC board, as shown on the overlay. Fit a small Nylon cable tie around the three wires to keep them together but not so close to the PC board that it causes undue strain on the wires.

The final step before calibration is to slide the heatshrink back down the three wires and all the way onto PC board, locating the pot access hole over the pot and then shrinking the heatshrink onto the PC board. A hot air gun is best but a hair drier on a high heat setting will work – it just takes a bit longer.

## Calibration

Before completing the Probe, now is the time to adjust trimpot VR1 for a division ratio of exactly 1000:1 – in other words, calibration.

Ideally, you'll need a convenient source of stable medium-high voltage to do this (say 750-950V DC).

If you don't have such a source your best plan would be to simply set VR1 to around the middle of its range, using one of your DMM's resistance ranges to do this. Simply connect the DMM leads directly across VR1, and turn its adjustment screw with a small screwdriver until you get a reading of close to 25kΩ. This should give your Probe a division ratio within about 3% of the correct figure.

If you do have a source of stable high voltage, calibrating the Probe is quite simple. You just need to be fairly careful, because high voltage can "bite"!

Having a banana socket with removable tip also makes it easier (and safer) to connect your high voltage to, as exposed metal is kept to a minimum.

You'll also need to connect the board's ground return lead pin (at the output end of the board) to the negative side of your high voltage source securely, before you start.

Measure and note down the voltage using your DMM directly, set to its top DC voltage range. Remove the DMM leads from the DC voltage source and connect instead the output leads from the Probe board.

Then connect the Probe's input socket to the positive side of the high voltage source, and you should be able to read the Probe's output voltage on the DMM. It should be very close to 1/1000th of the first reading and all you now have to do is adjust VR1 with a small screwdriver until it becomes as close as possible.

To end this procedure disconnect the probe tip from the positive side of the high voltage source, then disconnect the temporary ground return lead from the negative side and finally disconnect it from the ground lead pin in the rear of the Probe PC board. Your EHT Stick should now be calibrated, and ready for final assembly.

Give everything the once-over again, just in case – remember that once the end caps go on, they're rather difficult to get off again!

In fact, it's a good idea to loosely place the end caps as you follow the next steps and then make some trial measurements, just to make sure everything is still working.

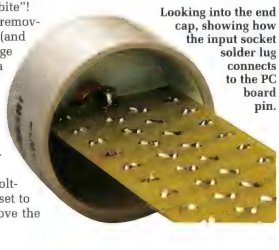
## It's complete!

Slide the pipe back down the wires and over the heatshrink-covered PC board. It's a snug fit but it does go in.

Place the front end cap onto the pipe now and slide the other end cap right back down the wires to the cable tie.

Leaving a small amount of slack inside the pipe, tighten the cable gland and then push the rear end cap loosely onto the pipe.

If your test measurements look satisfactory, push both end caps hard onto the pipe. No screws (or glue) are necessary to hold the caps in place – they won't come off by themselves! *SC*



**Looking into the end cap, showing how the input socket solder lug connects to the PC board pin.**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## *Interface your PC to the real world with this eigh*

# Arduino-compatible

***Want to control something – anything – with commands from your PC? Perhaps turn sprinklers on and off to water your garden? Maybe read some sensors? Or even sequencing Christmas tree lights in time with music? (OK, so we're getting in early!) Making the computer output the correct information is one thing. Interfacing that data to control real-word devices is another. That's what this nifty little relay box is all about.***

**The project**, developed by Ocean Controls, is based on the hardware of the Arduino physical computing controllers. It can be programmed as a stand-alone controller using the free, open source Arduino environment.

They've called it the "Relayduino", for obvious reasons.

Internally, the controller is "shield compatible", allowing the use of many extension boards designed for the Arduino Deumilanove (see the panel later in this article).

As shipped, the controller is loaded with a "sketch" (also see panel!) that receives simple commands over the USB or RS485 serial port and switches relays or responds with the status of inputs. This sketch is available on the Ocean Controls website as an example of Arduino programming for the controller.

Multiple controllers can be connected to one or more PCs in an RS485 network. Each controller can be assigned an address and will respond to commands addressed to them.

A simple ASCII protocol allows control from Windows/Mac/Linux using either USB Virtual COM drivers or RS485.

Additionally, multiple devices can be connected to one RS485 bus, allowing control

### Features

- 8 Relay outputs 5A 250VAC
- 4 Opto-isolated inputs 5-30VDC
- 3 Analog inputs (10-bit)
- Connections via pluggable screw terminals
- 0-5V or 0-20mA analog inputs, jumper selectable
- Power indicator LED
- Arduino compatible
- Accepts Arduino shields (Ethernet/XBee)
- USB virtual COM or RS485 input
- Suits Windows/Mac/Linux/etc
- Easily connect multiple units far apart by RS485
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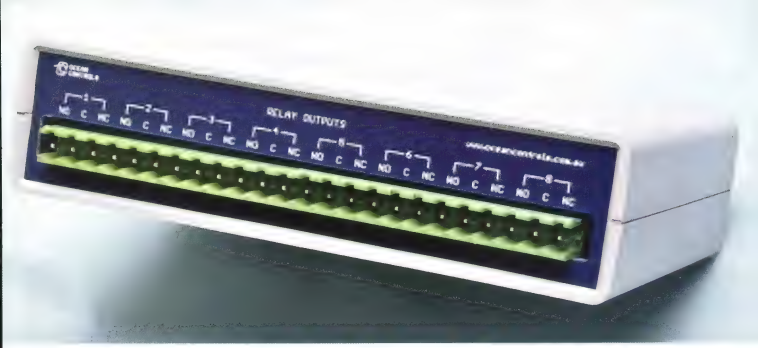



## hannel, USB/RS485

# I/O Controller

Design by Greg Radion#
Article by Greg Radion and Ross Tester

# Ocean Controls

of many devices from one USB port.

The relays are capable of switching up to 5A at 250VAC, 10A at 120VAC and 10A at 24VDC but the PC board tracks will only handle up to about 5A.

### But what can you do with it?

That, of course, is the $64,000 question – but in this case, the answer is simple: whatever you want!

The project described is simply a means of taking inputs, whether digital or analog and using those to switch relays under the software which you drive it with.

We're not going to go into a lot of detail here nor describe any of the software you'll need to perform the tasks required. Quite simply, that would be a near-infinite list, dependent entirely on exactly what it was that you wanted to control/sample/read/etc.

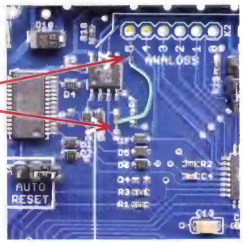
However, on the Ocean Controls website you'll find a few sample programs, including one which will flash your Christmas Tree lights!

A fair degree of experience is assumed in building this project. Perhaps it's even better to assume that by building and using this project, you'll gain a lot of experience!

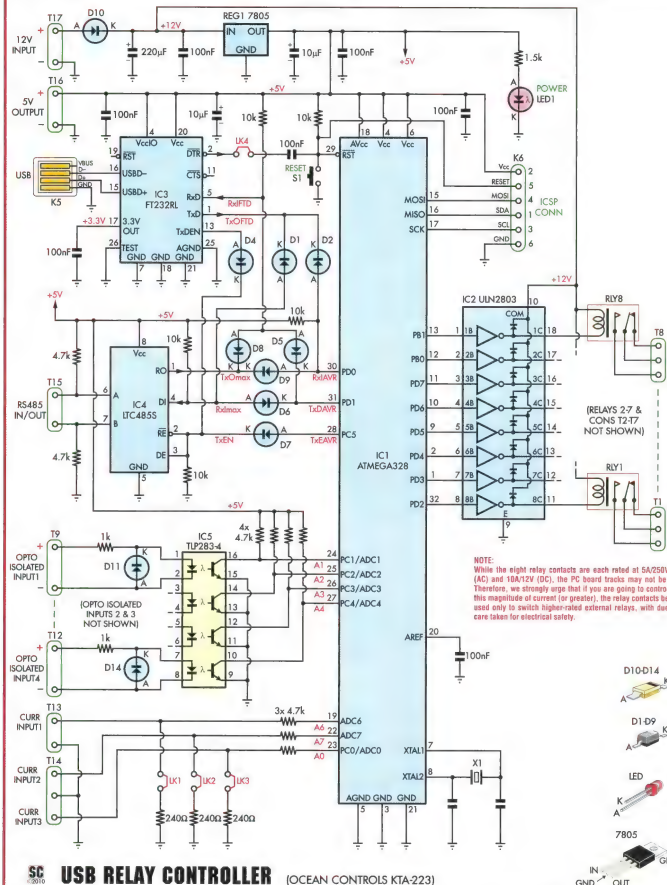
Because it is operated from low power (nominally 12V DC) it's very safe to experiment with. However, the relays are rated to switch mains voltages so we must be quite specific in our warnings regarding working with mains: if in doubt, don't!

### Specifications

| | |
|---|---|
| Power Supply: | 9-16V DC (12V Nominal) ~200mA + external 5V drain |
| Analog Input ANx: 0-5V: | ~500kΩ effective resistance with no jumper installed |
| 0-20mA: | ~250Ω effective resistance with jumper installed |
| Opto-isolated input: | 0-30V, ~1kΩ effective resistance |
| Relay outputs: | SPDT contacts rated to 5A (resistive), 250VAC / 30VDC |
| 5V auxiliary supply: | 200mA |




**If the PC board version is marked as KTA-223v1 then an insulated wire link needs to be soldered between the points shown here. Other PC board versions do not need this link.**




# SC 2010 USB RELAY CONTROLLER (OCEAN CONTROLS KTA-223)

Fig.1: The controller is based on the ATMEGA328 and is compatible with the Arduino platform.

You know that old adage "a little knowledge is a dangerous thing"? Nothing is truer when it comes to working with mains.

Note also the warning later on the limitations not only of the relay contacts but also of the current-carrying capacity of the PC board tracks.

## PC board assembly

The Relayduino kit comes partially assembled – all surface-mount components have already been placed, with the exception of three resistors that are not needed (R4, R5 and R7). Board assembly involves the addition of the through-hole components.

The PC board supplied in the kit may be one of two versions, depending on production. If yours is marked as KTA-223v1, then a wire link needs to be added. It is soldered between the via (the link between the top and bottom layers of the board) closest to the numeral "5" of the "Analogs" Header and the edge of the surface-mount resistor R8, closest to the text "R8" (see photo overleaf). If the board is marked KTA-223v2 or higher then no link is required.

However, check before adding the link to the v1 board, as Ocean Controls may well have already added the link for you!

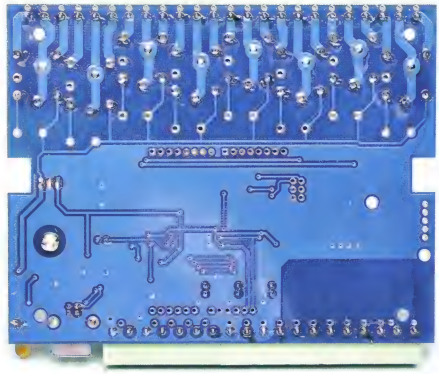
Next, add the header pins for the jumpers (or shunts). First cut the 8x1 header pin strip to make four lots of two pins each, then solder each two-pin set in place for J1, J2, J3 and J4. The matching jumper shunts (or shorting pin sets) can now be installed if the auto reset feature and 0-20mA signals are to be used.

There are quite a few right angle terminal sockets to solder in. Two 12-way connectors make up T1-T8 and one each of 12-way, 5-way and 2-way make up T9-T17, as shown in the component overlay and PC board silk screen. The sockets should be installed so that they overhang the edge of the PC board, as shown in the photo.

Next comes the 7805 regulator. Before soldering it in, the regulator legs should be bent 90° down with a pair of pliers so that when it is soldered to the board, its mounting hole lines up with the hole in the board.

Then it can be fastened to the heatsink (between the regulator and the board) using an M3 screw and nut.

It may be easiest to do this by pushing the screw through the regulator,



**You can increase the current-carrying capacity of the PC board tracks by filling the vias (the plated holes which pass from the bottom layer to the top layer of the board) with solder, as seen here. The tracks themselves (at the top of the board) are wider to carry the extra current but the copper within the vias is very thin. Filling with solder helps overcome this problem.**

**The bottom of the case needs to be modified as shown – the four inner PC board pillars need to be removed. This can be done with a pair of sharp sidecutters or the pillars can be carefully drilled away with a large drill bit.**

heatsink and PC board and determining the right "bend" position that way. Once sure you have got the position correct, solder the regulator in and trim the legs if they stick out too far beneath the board.

The USB socket and the relays are next to be soldered in. The USB socket shouldn't cause any drama but the relays need some explanation.

The PC board has been designed to accept two different relay types – a longer, skinnier type and a squat, squarer model. While the first type will fit the PC board, it is too tall to fit into the case. Therefore the supplied relays are the type that fit into the squarer of the two rectangles marked on the PC board surface.

When installing the eight relays it's best to solder them in one-at-a-time. They have the undesirable habit of dropping out when you flip the board over to solder the pins, so may want to hold them against a bit of card to prevent this.

Another way of achieving this is to use a *very* tiny piece of Blu-tak (about the size of a grain of rice) to hold the relay in place. It's non-conductive so doesn't matter if it stays under the relay once soldered.

Either way, ensure each of the relays is flush with the board before soldering.

There will be several unused holes in the PC board tracks below the relays. To ensure the tracks can carry the maximum current, fill each of these holes with solder once the relays are in place. (See Fig 2).

The final component to be fitted is the LED. Its legs should be bent to 90° and mounted so that the flat side of the body matches the flat side on the overlay/silkscreen. So that it can poke through the hole in the panel, it should be mounted approximately 8mm (to the centre of the LED) above the PC board surface.

Now that it's complete, before the PC board is screwed into the case check your soldering and ensure you haven't missed any joints or misplaced components.

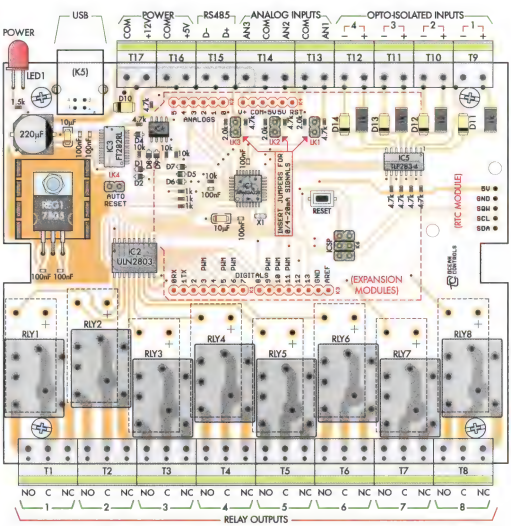



**Fig.2: full-size PC board component overlay, with matching photograph at right. The front panel labels are described in the table below left.**

## Front Panel Connections

| Label | Description |
|---|---|
| + | Opto-isolated input positive |
| - | Opto-isolated input negative |
| 5VO | 5V output for sensors |
| COM | Common connection (ground) |
| V+ | 12V power supply positive input |
| COM | Common connection (ground) |
| ANx | Analog input x |
| USB | USB B-type connection to PC |
| D+ | RS485 data+ |
| D- | RS485 data- |
| C | Relay common contact |
| NO | Relay normally open contact |
| NC | Relay normally closed contact |

## Fitting into the case

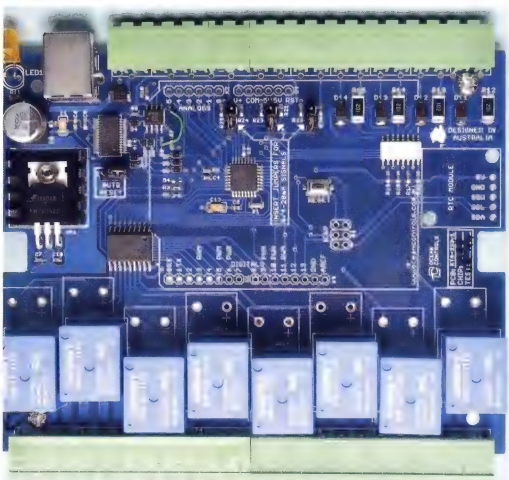
The case needs slight modification - the inner four screw mounting pillars need to be removed as they interfere with the mounting of the board (See photo overleaf). This is easiest with a pair of sidecutters – but be careful as the bits can shoot off! You could also use a large drill bit to remove them.

Put the front and rear panels over each end, with the terminal blocks poking through. Insert the assembly into the bottom section of the case – you should find the front and rear panels will slide into the side guides and channels quite easily.

Screw the main PC board to the case using the screws supplied. If you find one of the screws is difficult (or impossible) to fit, simply use only three of the screws.

To complete assembly, marry the top of the case to the bottom. It only goes one way, because there is an orientation lip on one side. The front and rear panels should easily fit into the channels on the lid. Screw it in place using the long countersunk screws.

## Jumper settings



## Parts List – Relayduino Controller

1 KTA-223 PC board, partly assembled with SMD devices
1 5mm LED
1 7805 5V regulator (TO-220)
1 TO-220 heatsink
1 USB "B" female socket
8 12V relays
3 12-way right-angle terminal sockets
1 5-way right-angle terminal sockets
1 8x1 Header pin set
1 2-way right-angle terminal socket
4 Jumper shunts
8 2-way plug-in terminal blocks
9 3-way plug-In terminal Blocks
1 ABS instrument case
1 Front panel
1 Rear panel
5 6mm M3 screws
1 M3 nut

**The above parts will be supplied in the Ocean Controls KTA-223 kit. Visit www.oceancontrols.com.au for more details and pricing.**

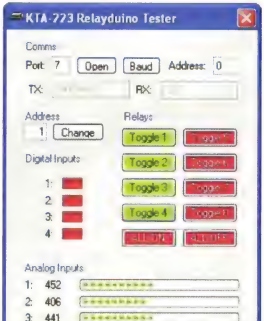
The analog inputs can be set for 0-5V or 0-20mA operation. Inserting jumper shunts in the positions J1, J2 or J3 will set the associated analog inputs to 0-20mA operation. Removing the shunts will set the analog inputs to 0-5V operation.

The analog inputs are protected with 4.7kΩ inline resistors. These will protect the microcontroller from damage for accidental input voltages up to 30V.

When the jumper labelled AUTO RESET is installed the board will reset each time a serial connection is made to the USB COM port. This should only be installed when reprogramming via the Arduino Environment, or the device will reset each time a serial connection is made to the unit.

## Using the controller

The controller requires a nominal 12VDC to operate. This can come from a plugpack, bench top power supply or battery and is connected to V+ and COM. The controller has screw terminals for the connection of power.




**The test software downloadable from** www.oceancontrols.com.au

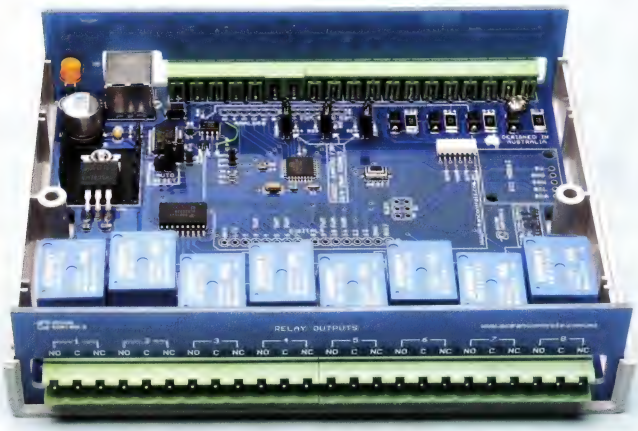
Plugpack power supplies often come with a plug on the end of the lead. The plug can be cut off and bare wires exposed for the screw terminals on the controller.

Connect the power supply positive to the V+ terminal and negative to the COM terminal next to it. The POWER LED should light.

A series diode (D1) protects the controller by preventing it from operating with power connected in reverse polarity. If the LED does not light, ensure your supply is delivering sufficient voltage and is connected the right way around.

## Connections

Connect the controller to a computer using a USB-A male to USB-B male cable. When the power is turned on your computer may prompt you to install drivers. The drivers required are the FTDI Virtual




**Here's the completed unit mounted inside the case, looking from rear to front. Connection is made to the input and output sockets by means of plug-in terminal blocks, not shown in this photo.**

COM Port Drivers the latest versions for all systems are available from www.ftdichip.com/Drivers/VCP.htm

The Ocean Controls website also has a number of possible input and output configurations for you to experiment with.

## Test Utility

The main window of the Windows test utility is shown overleaf.

If the Address of the unit you wish to control is known put it in the "Address" text box, if not, use 0 for the address and any unit will respond.

Enter the COM Port number in the "Port" text box, if this is not known it can be found in the device manager under ports.

The quickest way to run device manager is by clicking Start->Run and then typing "devmgmt.msc".

Once the device is communicating, relays can be turned on or off by clicking the buttons in the Relays group and the status of the Digital and Analog Inputs are shown in their relevant groups.

The source code for this program is available from Ocean Controls and is written in Visual Basic Express 2008 which is available free from Microsoft.

Ocean Controls can also supply a similar example program with source code for Visual Basic 6.

## Communicating with the controller

The Address and Baud Rate of the unit can be set and are stored in the controller's memory. By default the controller is listening for serial data at 9600 baud, and has address 00. The controller will always use 1 Stop Bit, 8 Data Bits and No Parity.

The commands the controller uses are in the form

**@AA CC X<CR>**

The @ symbol is used to define the start of a command.

**AA** is the address of the unit from 00 to 99.

**CC** is a two-letter command used to determine the command type.

**X** is a one or more characters which determines the parameter for the command.

**<CR>** is the carriage return character. This is ASCII character 13, or 0x0d.

Each time a valid command is received the unit will respond with #AA followed by any values that are requested from the unit.

See the panel overleaf for a list of commands.

Note that 00 is the Wildcard Address. If a command has 00 as the address, all devices will respond as if they have been individually addressed.

**Where from, how much?**

You'll find much more information, including current pricing, instructions and software downloads, etc, on the www.oceancontrols.com.au website

# Using the controller as an Arduino device

The unit as supplied is an Arduino-compatible board with Arduino bootloader and a custom sketch loaded that responds to the serial commands listed overleaf. The source code of this is available from Ocean Controls and can be modified in the Arduino environment to suit your purpose.

The Arduino programming environment can be downloaded for Windows, Mac OS X and Linux from www.arduino.cc

When using the Relay Controller with the Arduino Environment select "Arduino Duemilanove w/ ATmega328" from the "Tools->Board" menu, and install the "AUTO RESET" jumper on the PC board for ease of programming.

The hardware has been designed to accept the Arduino compatible Shields. The cover may not be able to be installed when using larger shields. Some shields may require removal or modification of the back panel to fit overhanging components (the Libelium XBee shield fits with XBee modules using chip antennae but SMA antenna connections conflict with the back panel).

The V1 controller PC board does not locate the 6-pin ICSP in the same position as the Arduino Deumilanove. Some shields (notably the Libelium XBee shield) take 5V power, ground or other signals from the ICSP header. These shields must be supplied power or signals from the standard Arduino header rows, or extended from the ICSP connection on the controller to the shield.

The Libelium XBee shield must be supplied with 5V power by connecting 5V on the shield to K6 Pin 2 and GND on the shield to K6 Pin 6.

Space is provided on the PC board to install the SparkFun Real Time Clock module (SparkFun part: BOB-00099). The intention is to allow the controller to operate in stand alone situations that require more timing flexibility than the stock controller can provide. The PC board connects the RTC module SDA to Arduino Digital 12 and SCL to Arduino Digital 13. Installing this unit may prevent proper operation of other modules or shield that rely on these pins (for example, the Ethernet shield cannot be used with the RTC module).

The RS485 transceiver is connected in parallel with the FTDI USB to Serial converter and ATMega328 UART pins.

This transceiver allows half-duplex serial communication over 2 or 3 wires. The transceiver requires a TX Control signal to enable the transmit or receive line driver. When transmitting, the TX Control line must be asserted (driven high). To receive, the line must be left low.

The FT232RL USB to Serial converter provides a TXEN signal for RS485 Transceivers. When data is received from the USB port by the FT232RL, it asserts the TX Control line, putting the RS485 transceiver in Transmit mode.

The serial data is then transmitted to the ATMega328 and onto the RS485 network.

Using the RS485 transceiver from custom Arduino code requires that your code drive the TX Control line high at the beginning of data transmission and returns it low at the end of the transmission. The TX Control line is connected to Digital 19. The Ocean Controls sketch provides an example of how to do this.

The table below shows the mapping of Arduino pins to the inputs and outputs of the controller.

## Arduino Pin Mapping

| KTA-223 IO | Arduino Pin | AVR Port.Pin |
|---|---|---|
| Relay 1 | Digital 2 | PORTD.2 |
| Relay 2 | Digital 3 | PORTD.3 |
| Relay 3 | Digital 4 | PORTD.4 |
| Relay 4 | Digital 5 | PORTD.5 |
| Relay 5 | Digital 6 | PORTD.6 |
| Relay 6 | Digital 7 | PORTD.7 |
| Relay 7 | Digital 8 | PORTB.0 |
| Relay 8 | Digital 9 | PORTB.1 |
| Opto-In 1 | Digital 15 / Analog 1 | PORTC.1 |
| Opto-In 2 | Digital 16 / Analog 2 | PORTC.2 |
| Opto-In 3 | Digital 17 / Analog 3 | PORTC.3 |
| Opto-In 4 | Digital 18 / Analog 4 | PORTC.4 |
| Analog In 1 | Analog 6 | ADC6 |
| Analog In 2 | Analog 7 | ADC7 |
| Analog In 3 | Analog 0 | PORTC.0 |
| RX Data | Digital 0 | PORTD.0 |
| TX Data | Digital 1 | PORTD.1 |
| RS485 TX Control | Digital 19 / Analog 5 | PORTC.5 |
| Ethernet Shield | Digital 10 | PORTB.2 |
| Ethernet Shield | Digital 11 | PORTB.3 |
| Ethernet Shield / RTC SDA | Digital 12 | PORTB.4 |
| Ethernet Shield / RTC SCL | Digital 13 | PORTB.5 |

## What is Arduino?

Arduino is an open-source microcontroller development environment consisting of hardware in the form of an AVR development board, software for Windows, Mac and Linux and firmware in the form of a bootloader programmed in to the AVR microcontroller on the development board.

Arduino is similar to PICAXE or the BasicStamp but open source, for the Atmel AVR and cross platform.

Arduino was developed to enable virtually anyone, from artists to engineers, to get up-and-running with microcontroller programming and real world interaction, without the need to dig through data sheets, design PC boards or have an engineering degree.

The hardware is cheap (less than $40) for the basic Arduino Duemilenove. No further tools are needed: just plug it into a USB port, download the software to your PC and you can program it straight away.

Speaking of programming the Arduino, it is done using "C". The program is called a "sketch" and is broken into initialisation and main program sections. Many examples for all sorts of sensors and interfaces are supplied.

The expansion boards for the Arduino are called "shields" and are designed to plug in to the top of the main board. Multiple shields can be stacked on top of each other.

The Ocean Controls KTA-223 Relay Controller has been loaded with the Arduino bootloader and a sketch which interprets the serial commands and operates the Relays.

If someone wishes to alter the protocol, or reprogram the unit, they can do so without the need of a programmer.

For more details on Arduino, take a look at **www.arduino.cc**

## Command Set

| Letter | Command | Parameters | Notes |
|---|---|---|---|
| **ON** | **Turn relay On** | 1-8: Turn Relay 1-8 On Individually<br>0: Turn All Relays On at Once | *This command is used to turn a single relay on. Eg, @44 ON 1 will turn relay 1 on for the unit with address 44. It can also be used to turn all the relays on, this occurs when the parameter value is 0.* |
| **OF** | **Turn relay Off** | 1-8: Turn Relay 1-8 Off Individually<br>0: Turn All Relays Off at Once | *Similar to the on command this command will turn relays off in the same manner. Eg, @44 OF 1 will turn relay 1 off for the unit with address 44; @44 OF 0 will turn all relays off.* |
| **WR** | **Write to all relays** | The parameter is a number which determines which of the relays should be turned on or off. | *The write relays command is used when more than one relay is to be turned on or off at once. The parameter is a decimal number which, in binary, represents the on and off status of the 8 relays. The least significant bit of this value controls relay 1. The most significant bit of the parameter value controls relay 8. A set bit (1) turns the relay on, a cleared bit (0) turns the relay off.*<br><br>*Example: To turn relays 1, 2 and 6 on (and others off) the binary value required is 00100011. In decimal this is 35. (2^(1-1) + 2^(2-1) + 2^(6-1) = 35). To issue this to a controller with address 44, the required command is @44 WR 35* |
| **IS** | **Status of inputs** | 1-4: Returns Status of Inputs 1-4 Individually<br><br>0: Returns Status of All Inputs | *This command will return the status of the inputs. If the parameter is between 1 and 4 then the controller will return a 0 or 1 corresponding to that input. Eg, @44 IS 1 will return #44 1 if the input is on, or #44 0 if the input is off. If the parameter is 0 then the unit will respond with the status of all the inputs, in similar form as the Write Relays command. Eg, if inputs 1 and 2 for the unit are on then @44 IS 0 will return #44 3. 3 is 0011 in binary, and each bit represents each input from 4 down to 1.* |
| **RS** | **Status of relays** | 1-8: Returns Status of Relays 1-8 Individually<br><br>0: Returns Status of All Relays | *Much the same as the input status command, this command will return the status of the relays. If the parameter is between 1 and 8 then the unit will return with a 0 or 1 corresponding to that relay. Eg, @44 RS 1 will return #44 1 if the relay is on, or #44 0 if the relay is off. If the parameter to this command is 0 then the unit will respond the same way as the input status command, but return the status of the relays.* |
| **AI** | **Read analog input** | 1-3: Read Value of Analog Input 1, 2 or 3<br>0: Returns Value of All Analog Inputs | *The analog input command will read the status of the analog input defined by the parameter and return it as a value between 0 and 1023. Eg, @44 AI 1 will return #44 512 if the analog input is reading 50%.* |
| **SA** | **Set address** | 01-99: Sets the Address of the unit in Memory | *Addresses are valid from 01-99. A unit will only respond if its address in memory is the same as that of the command sent, or if the address of the command sent is 00. The address is saved to non-volatile memory inside the controller, meaning it will be preserved even after power is disconnect from the controller.* |
| **SB** | **Set baud rate** | 1-10: Sets the Baud Rate<br>1: 1200 baud 6: 19200 baud<br>2: 2400 baud 7: 28800 baud<br>3: 4800 baud 8: 38400 baud<br>4: 9600 baud# 9: 57600 baud<br>5: 14400 baud 10: 115200 baud | *The baud rate is saved to non-volatile memory inside the controller, meaning it will be preserved even after power is disconnected from the controller.*<br><br>*(# default)* |

SC

# PICOTEST M3510A

# 6½ Digit Multimeter

**The M3510A is a fast, accurate 6½ digit bench-top multimeter with 4-wire resistance measurement, thermocouple support and a USB interface. Its maximum ratings are 1000V DC and 10A and it can take up to 50,000 readings per second.**

**Review by Nicholas Vinen**

**The PICOTEST M3510A bench-top multimeter** has an impressive array of features. It is a great deal more accurate than a typical hand-held multimeter and comes with a calibration certificate.

Precision figures are provided for each measurement mode over various lengths of time, up to 1 year. Accuracy for most readings is in the order of ±0.01%.

It has a very fast measurement update rate; up to 50k samples per second. While the display is not updated anywhere near that rapidly, it is still noticeably faster than most other multimeters – even other bench meters.

When it is in auto-ranging mode you do not have to wait long for it to find the correct range for your measurement. Alternatively, you can select the appropriate range yourself using two front-panel buttons.

To take maximum advantage of the fast measurement rate you need to connect it to your computer – more on that later.

While a bench multimeter takes up more space than a hand-held unit, in some ways it is more convenient to use. The controls and connections are easier to access and the display is easier to read.

They also tend to have more features, better performance and since they run off mains power, you never need to worry about a flat battery.

The main body is 227mm wide, 305mm deep and sits 150mm high with the handle set up as a tilting bail. It has a 2-line orange-on-black backlit LCD with quite a wide viewing angle which is better to the left than to the right.

Since the connectors are on the right side, this means it is best located on the right side of the bench.

On the rear panel are BNC trigger inputs and outputs, a USB socket, an IEC power socket, an earth screw and the optional GPIB/RS-232 interface connector. Two high quality needle probes are provided in the box.

## Measurement modes

The main modes are DC volts and amps, AC volts and amps (with true RMS), 2-wire or 4-wire resistance, capacitance, frequency, continuity, diode test/forward voltage and temperature.

In DC volts mode, the input impedance is 10GΩ (gigaohms) for ranges up to 10V and 10MΩ for higher ranges. This can be overridden if you want 10MΩ impedance for all ranges.

The 10GΩ mode is very handy for measuring voltages with a very high source impedance. This is because much less current is drawn from the point you are measuring than a typical hand-held multimeter.

The 4-wire resistance mode allows for much more accurate measurement of smaller value resistors, with readings down to 0.1mΩ (milliohms).

Practically speakingthough, readings below 10mΩ are hard to make accurately, due to temperature drift, noise and probe resistance, even in the 4-wire mode.

To use the 4-wire mode you will need to add another pair of probes or buy one of the optional accessories such as the OPT07 Kelvin Probe Set or OPT08 4 Wire Test Probe.

For temperature measurements both RTDs (resistance temperature detectors) and thermocouples are supported. The M3510A is supplied with a K-type thermocouple and it has internal cold junction compensation.

This is a major selling point for this unit as temperature can be read out with up to four decimal places, although the actual accuracy of the reading is only about one degree.

## Interface and useability

Using this multimeter for basic measurements is a joy and its fast updates are a revelation after using typical handheld digital multimeters.

Its capacitance mode ranges from fractions of a picofarad up to thousands of microfarads – very handy indeed. Connect virtually any unknown capacitor and you will have its value, although larger capacitances can take several seconds to measure.

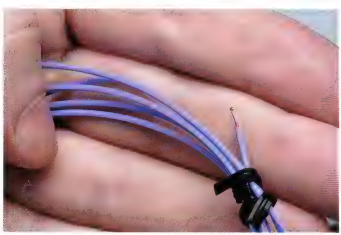
The frequency measurement mode is very accurate but does not have a very wide range – only 3Hz to 300kHz. The update rate is automatically adjusted and is quite fast except when measuring very low frequencies.

The interface is easy to use and it responds instantly to button presses. Pressing each button generates a beep but that can be disabled.

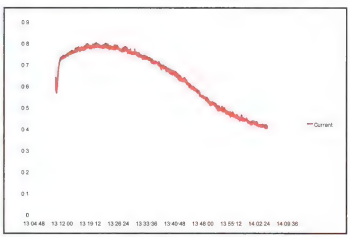
All the most important functions take just one or two button presses. There is also a menu system, which is used for changing the configuration and to enable the various mathematical modes.

Sometimes it isn't entirely obvious where a given option will be in the menu but there are not so many that it takes very long to go through them all.

Options available through the menus include changing the ADC sample



**This oversize photo shows the supplied thermocouple: it's tiny (the silver blob at the end of the wire). It's so small that at first, we didn't think it had been supplied.**




**The charging current flowing into a small SLA battery. Current measurements were taken once per second and when finished we imported the CSV file into OpenOffice to draw the chart.**

period, ratio measurements, averaging, limit testing, min/max readout, mX+b readout, dB readout and auto-hold.

More commonly used mathematical operations such as offset nulling and filtering are provided directly via buttons on the front panel.

The "DIGITS" button allows for selectable precision in all modes. As you increase the number of digits, the update rate slows down but even in 6.5-digit mode it is quite fast.

In addition there are several filter settings which can be used to further adjust the speed/precision trade-off.

The 2-line display means that in virtually every mode it is possible to make two measurements at once. However, because the acquisition circuitry is shared, the ground reference terminal is common and the update rate is reduced in dual display mode.

While it is very handy, for the aforementioned reasons the dual measurement function isn't quite as good as having two separate meters.

For example, you can measure voltage and current at the same time but they must both be relative to the same point in the circuit. While in dual measurement mode, a relay click is evident each time the display is updated, unless one measurement is from the thermocouple input.

## Computer interface

While some high-end hand-held multimeters do provide computer connectivity, the M3510A takes it to a whole new level.

Plugging it in means, essentially, that you have added a very accurate and high speed ADC to your computer, with all the front-ends the multimeter provides.

As already stated, to make use of the maximum 50k sample rate you need to hook the multimeter up to a computer via the provided USB cable. This allows you to use it as a data logger.

You can use the fast sample rate to record what happens in a circuit over a short period or else set the rate lower, for long-term logging.

The software provided is simple but does the job. You can select any of the main measurement modes from the GUI and once you choose an update rate and click "play" it begins logging data. It can later be imported into Word or Excel via a CSV (comma separated variable) file.

The drivers on the provided CD were too old to work with Windows 7 64-bit edition but a newer version is available for download which solves this problem.

At the time of writing, the software does not support logging multiple inputs in one session but we have been informed by the distributor that a new version, which can do so, should be available around the time this goes into print.

Overall, we are impressed with the PicoTest M3510A. Its ease-of-use, accuracy and features combine to make this a powerful test instrument.

## Availability

The M3510A is available from Westek for AU$825.00 plus GST and delivery. The M3511A model with 10k/s sample rate and no thermocouple input is AU$692.00 plus GST and delivery.

In both cases the standard warranty is one year but it can be extended at additional cost.

To contact Westek, call (03) 9369 8802 or e-mail info@westek.com.au. For further information visit www.westek.com.au.

SC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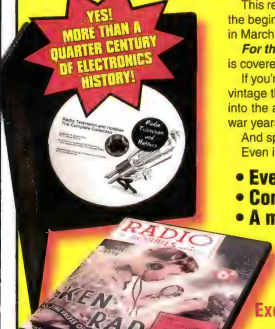

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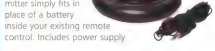

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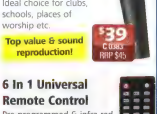

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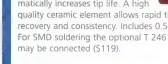

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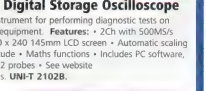

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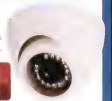

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**Last month, we described how the S/PDIF Digital Audio Signal Generator works. This month, we describe how to assemble the PC boards, mount them in the case and check that they are working correctly.**

By NICHOLAS VINEN

# A High-Quality Digital Audio Signal Generator; Pt.2

THE DIGITAL AUDIO Signal Generator is built on two PC boards: a main board and a control board. Construction can begin with the assembly of the main PC board. There are two versions, one to suit the Jaycar case (Fig.10) and the other to suit the Altronics case (Fig.11). The Jaycar main board is coded 04203101 while the Altronics board is coded 04203103.

Before starting, examine the copper side of the PC board for any defects. It's also a good idea to place it inside the case, up against the end, in order to check that it fits properly. Verify that the mounting holes line up with the posts in the base of the enclosure.

Once you are satisfied that it will fit, start the assembly by installing the seven wire links. You can use 0Ω resistors for the shorter links and 0.71mm tinned copper wire for the longer ones (or you can use tinned copper wire for the lot).

Next, install the 0.25W resistors. It's best to check the value of each with a DMM before installation, as the colour codes can be hard to read.

Follow these with the four diodes (D1-D4) and zener diode ZD1. Pay careful attention to the orientation of these parts. You will have to bend the leads of the 1N5819s close to their bodies for them to fit.

The five IC sockets can now be installed. Be sure to line the notches up with those shown on the overlay. Solder two diagonally opposite pins on each to begin with, then check that they are sitting flat on the PC board before soldering the rest.

Crystals X1 and X2 are next on the list. Be careful not to get them mixed up. The markings on their cases should match the corresponding frequency values on the PC board overlay.

Once these are in place you can install the 10Ω 1W resistor (see panel). If you install it, you can only use rechargeable cells or the plugpack to power the device – you cannot use alkaline or other non-rechargeable batteries. **If you do want to use alkaline batteries (or the plugpack), then leave this resistor out.**

Since the physical size of this resistor can vary, you will need to make sure that it doesn't interfere with the battery connector. If necessary, install it slightly proud of the PC board so

that it sits above the adjacent 1N5819 diode (D2).

Follow with the two TO-220 voltage regulators (REG1 & REG2), taking care not to get them mixed up. In each case, bend the leads down through 90° about 5mm from the body using a pair of needle-nose pliers. That done, mount the device on the board, line up the tab mounting hole and secure it using an M3 x 6mm machine screw, nut and star washer (the latter goes under the head of the bolt).

Finally, solder the leads to their respective pads and trim away the excess. Do not solder the leads before you have bolted the devices down, otherwise you could crack the copper tracks as the screw is tightened.

The next step is to install the IDC (insulation displacement connector) socket (CON4). It should be installed with its notched side towards the bottom (see layout diagram). Solder pins 1 & 16 first and make sure the socket is sitting flush against the board before soldering the rest.

## Installing the transistors

Transistors Q1-Q7 can now be fitted. These all come in TO-92 plastic packages but there are three different types, so read the markings carefully.

In some cases, the leads may be too close to fit through the mounting holes. If so, use needle nose pliers to bend the two outer legs apart to 45°, close to where they emerge from the case, and then back parallel again further down, so that they will fit in place.

The three polarised header connectors (CON1-CON3) go in near the bottom edge of the board. Be sure to orient them as shown and make sure they are sitting flat against the board before soldering their pins.

Now fit the capacitors, starting with the MKT and ceramic types. These can go in either way around. Once these are all in, install the electrolytics. Their orientation does matter so make sure they go in the right way around.

Be extra careful with the tantalum capacitor, which is also an electrolytic but uses a different electrode material. It's easily destroyed by reverse polarity. The only reliable way to check the orientation is to look for the "+" sign printed on the epoxy case, above one of the legs.

The main board assembly can now be completed by installing the 100µH inductor, the TOSLINK transmitter and the three RCA sockets. When mounting the TOSLINK transmitter, push its two plastic posts down through the holes in the board until they snap in, then check that it is sitting flat and parallel with the edge of the PC board before soldering its pins.

Be sure to use a white RCA socket for the left analog output, red for the right analog output and black for the S/PDIF output. You may have to press the sockets down hard into the board to get their plastic posts to sit properly. Note that they do not go all the way down through the board but rather sit in the holes.

Ensure that the RCA socket bases are sitting parallel with the PC board before soldering them in place. It is best to check them from the perspective of the sides and end of the PC board as they can be mounted askew in either plane.

That completes the main assembly

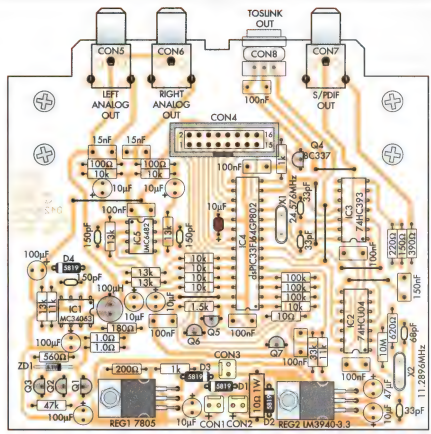



**Fig.10: follow this diagram to build the main PC board for the Jaycar case. Make sure that all polarised parts are correctly oriented and install the 10Ω 1W resistor only if you intend using rechargeable cells (see panel).**

## Choosing The Trickle Charge Resistor

As mentioned in Pt.1, Nickel Metal Hydride (NiMH) rechargeable cells can be used to power the unit and the circuit includes a 10Ω 1W resistor to trickle charge them whenever the plugpack is connected. This resistor value is suitable for 2000mAh cells and provides just under 100mA to the cells once they are fully charged

This equates to a charge rate of C/20 for 2000mAh cells, although it will be appreciably higher than this when the cells are flat.

If you use lower capacity cells, then you need to increase the value of the resistor accordingly. For example, 800mAh cells require a 27Ω 1W resistor, while 600mAh cells require a 33Ω 1W resistor.

Note that you should install this resistor only if you intend using NiMH or Nicad cells in the device. Do not install it if you intend using alkaline (or any other non-rechargeable) cells.

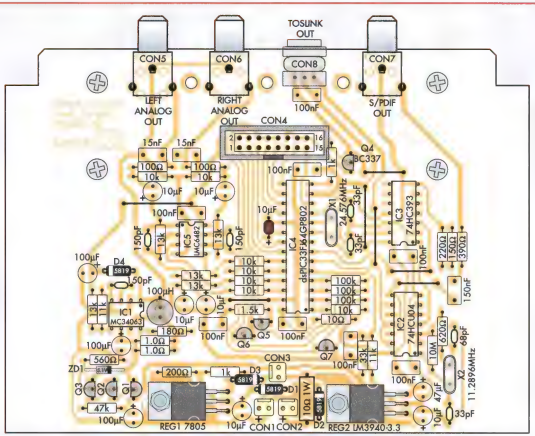



**Fig.11: this is the alternative main board layout to suit the Altronics case. The circuit layout is almost identical to the Jaycar version but the mounting holes and output sockets are in slightly different locations. The diagram at top right shows how to wire the DC socket (both versions).**

## Table 1: Resistor Colour Codes

| ❑ | No. | Value | 4-Band Code (1%) | 5-Band Code (1%) |
|---|---|---|---|---|
| ❑ | 1 | 10MΩ | brown black blue brown | brown black black green brown |
| ❑ | 3 | 100kΩ | brown black yellow brown | brown black black orange brown |
| ❑ | 1 | 47kΩ | yellow violet orange brown | yellow violet black red brown |
| ❑ | 2 | 33kΩ | orange orange orange brown | orange orange black red brown |
| ❑ | 4 | 13kΩ | brown orange orange brown | brown orange black red brown |
| ❑ | 2 | 11kΩ | brown brown orange brown | brown brown black red brown |
| ❑ | 7 | 10kΩ | brown black orange brown | brown black black red brown |
| ❑ | 1 | 1.5kΩ | brown green red brown | brown green black brown brown |
| ❑ | 2 | 1kΩ | brown black red brown | brown black black brown brown |
| ❑ | 1 | 620Ω | blue red brown brown | blue red black black brown |
| ❑ | 1 | 560Ω | green blue brown brown | green blue black black brown |
| ❑ | 1 | 390Ω | orange white brown brown | orange white black black brown |
| ❑ | 1 | 220Ω | red red brown brown | red red black black brown |
| ❑ | 1 | 200Ω | red black brown brown | red black black black brown |
| ❑ | 1 | 180Ω | brown grey brown brown | brown grey black black brown |
| ❑ | 1 | 150Ω | brown green brown brown | brown green black black brown |
| ❑ | 2 | 100Ω | brown black brown brown | brown black black black brown |
| ❑ | 1 | 10Ω | brown black black brown | brown black black gold brown |
| ❑ | 1 | 5.6Ω | green blue gold brown | green blue black silver brown |
| ❑ | 2 | 1Ω | brown black gold gold | brown black black silver brown |

**Table 2: Capacitor Codes**

| Value | µF Value | IEC Code | EIA Code |
|---|---|---|---|
| 150nF | 0.15µF | 150n | 154 |
| 100nF | 0.1µF | 100n | 104 |
| 15nF | 0.015µF | 15n | 153 |
| 150pF | NA | 150p | 151 |
| 68pF | NA | 68p | 68 |
| 33pF | NA | 33p | 33 |

but leave the ICs out of their sockets for the time being.

## Building the control board

Fig.12 shows the parts layout for the control board. Start by installing the seven 1N4148 small signal diodes (D5-D11). They all face in the same direction. That done, install the IDC socket with the orientation shown, then install the 5.6Ω resistor and the single 100nF MKT capacitor.

The way in which the LCD is mounted depends on which case you are using. Don't remove the protective plastic from the top of the LCD yet.

**(1) Jaycar case:** if you are using the Jaycar case, begin by fitting M3 x 6mm machine screws through the holes on the control board (ie, either side of the LCD position), with the head on the copper side. Next, thread an M3 nut onto each screw until it is tight and screw an M3 x 9mm tapped Nylon spacer down on top.

The LCD connects to the PC board via male and female 16-pin headers. For the time being, just loosely insert the long pins of the male header into the female header.

**(2) Altronics case:** for the Altronics case, first fit an M3 x 6mm screw through the holes on either side of the LCD position (head on the copper side), then screw on an M3 x 9mm Nylon spacer (ie, no nut). That done, use a pair of pliers to pull the pins out of the plastic spacer of the male pin header. These must then be fully inserted, one at a time, into the holes of the female header.

When you are finished, you can discard the leftover plastic spacer.

## Mounting the LCD

You are now ready to mount the LCD. Begin by placing the female header's pins into the row of 16 holes on the PC board, then sit the LCD on top. The upwards-facing pins should fit into the corresponding row of holes on the LCD board. You then secure the LCD module using M3 x 6mm machine screws which go through the LCD module and into the Nylon spacers.

It's now just a matter of soldering the pins on the underside of the control board and on the top of the LCD module. There are 32 in all, so don't miss any and be careful to avoid shorts between them.

## Pushbutton switches

Now that the LCD is in position, it's time to install the seven tactile switch buttons. Their bases are rectangular, so you can't install them the wrong way.

To install each switch, first insert its angled pins through the holes and push it down so that it sits flat against the PC board. Check that the shaft is as close to vertical as possible, then solder all four pins. Be careful that the buttons don't move when you turn the assembly over to solder them.

## Completing the control board

Having fitted the switches, the con-

**This is the view inside the Jaycar case after the main board, power switch (top right), DC socket (top left) and cell holders have been installed. The cell holders are connected in series.**

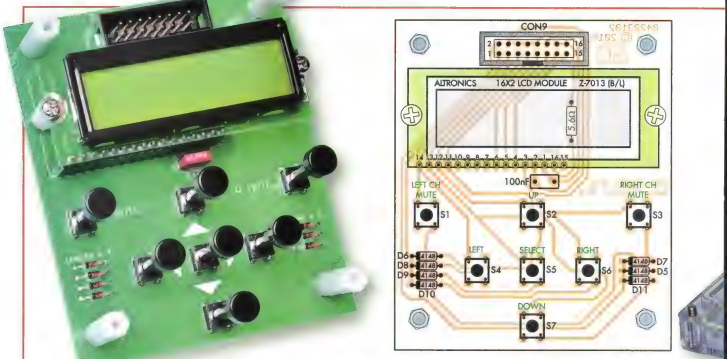



**Fig.12: follow this parts layout diagram and the photo at left to build the control board. Note that the mounting arrangements for the LCD depend on the case you will be using – see text.**

trol board can be completed by fitting its mounting screws and spacers.

Begin by inserting an M3 x 15mm machine screw through each of the four corner mounting holes (with the head on the copper side), then thread an M3 x 9mm tapped Nylon spacer over each screw and tighten it down. When that's done, each screw should protrude about 4mm beyond its spacer.

The next step depends on the case you are using. If you have the Jaycar case, simply screw an M3 x 12mm Nylon spacer down over each exposed screw. Alternatively, for the Altronics case, fit two M3 star washers over each screw, then screw down another M3 x 9mm tapped Nylon spacer on top.

When you have finished this step, the spacer ends should be slightly above the level of the LCD. You can now remove the protective plastic coating from the LCD and place the control board to one side while you run some basic tests.

## Testing the main board

It's a good idea to test the main board before going any further. You can either use a bench supply (set at 9.5V with a current limit of 150mA) or a 7.5-10V DC plugpack with an ammeter in series.

If you are going to use an unregulated plugpack, 7.5V may be the best choice since it will deliver a higher voltage due to the relatively light load – probably at least 9V. Check with a voltmeter if you are unsure. If the no-load voltage output is above 9V and the current rating is at least 500mA it should be fine.

Place a shorting link (or "jumper") across the switch pin header (without it, the circuit will not turn on). Also, make sure none of the ICs are installed in the sockets.

Next, apply power via the external DC header (CON1) – not the battery header – and observe the current reading. It should be less than 10mA.

If that checks out, measure the voltage at the output of each TO-220 regulator using your DMM. In each case, place the black probe on pin 2 or the tab and the red probe on pin 3. You should get readings of 6.8V ± 10% for REG1 and 3.3V ±5% for REG2.

If any reading is wrong, switch off immediately and check that all parts have been installed correctly.

Now measure the voltage between pins 6 & 4 of the socket for IC1 (MC34063). It should be close to 5.0V. If it is below 4.7V or above 5.2V, then check the voltage across ZD1.

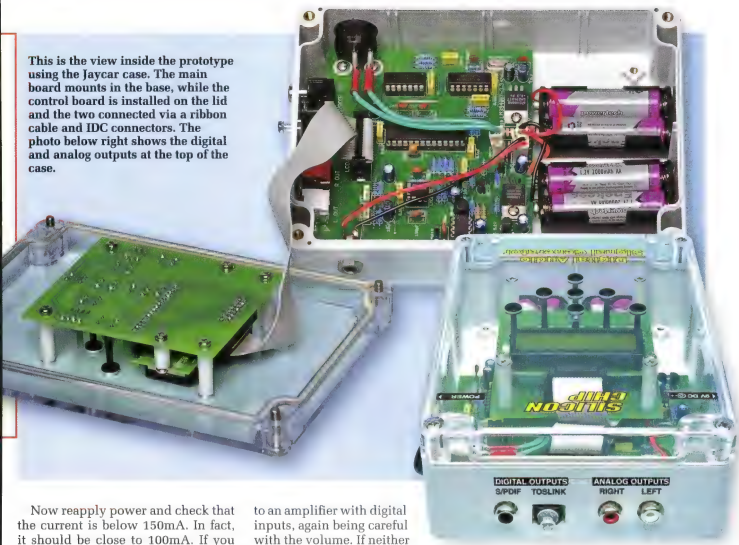
Because low-voltage zener diodes have a relatively high impedance, you will find it is well below its rated voltage of 5.1V. We want it to be around 4.3V. If yours does not read between 4.0V and 4.5V then that will be the reason for IC1's voltage reading being out of range. In that case, you will need to try a different zener diode with a different voltage rating or try one from a different manufacturer.

The most likely types to be suitable are 4.7V and 5.1V zeners but unfortunately there is no easy way to tell without measuring it.

Once the supply voltage is within the acceptable range, turn the power off and install IC1 (MC34063), ensuring its orientation matches the socket. If you are using a bench supply, set it to 7.0V, reapply power and again check that the current is less than 10mA.

Now measure the voltage between pins 8 & 4 of IC5's socket. It should be 5.0V ± 5%. If not, there is a problem with the MC34063 IC or the surrounding components.

Turn the power off again and install IC4 (dsPIC33). Make sure it has been programmed with the appropriate software and that it is installed with the correct orientation. Also, install the three remaining ICs – IC2, IC3 and IC5. Don't get the 74HC04 and 74HC393 ICs mixed up as they have the same number of pins.




**This is the view inside the prototype using the Jaycar case. The main board mounts in the base, while the control board is installed on the lid and the two connected via a ribbon cable and IDC connectors. The photo below right shows the digital and analog outputs at the top of the case.**

Now reapply power and check that the current is below 150mA. In fact, it should be close to 100mA. If you have a frequency counter, measure the frequency at pins 6 & 8 of IC3 (74HC393) relative to pin 7 (ground). Pin 6 should read 705.6kHz and pin 8 should read 1.536MHz. If not, check the crystal oscillators and the circuitry surrounding IC3 for mistakes.

If the pin 6 reading is correct but the pin 8 reading is not, there could be a problem with IC4's (dsPIC33) oscillator circuit. Check its power supply.

## Testing the outputs

The next step is to test the analog outputs. When powered up for the first time, both channels should output a full scale (1V RMS) 1kHz sinewave after a couple of seconds.

You can test them by connecting them to an oscilloscope or to an audio amplifier. If you use an amplifier, make sure its volume is turned well down before applying power to the signal generator. If they do not work properly, check the circuitry around IC5 (LMC6482).

To test the digital outputs (S/PDIF & TOSLINK), connect them to a DAC or to an amplifier with digital inputs, again being careful with the volume. If neither output works, the dsPIC33 may not be programmed correctly or it may not be functioning due to incorrect parts placement or an incorrect power supply.

## Testing the control board

Now that the main board is working, it is time to connect the control board. First, you will need to make a ribbon cable. One option is to use an IDC crimping tool such as the Altronics T1540 or Jaycar TH1941 but if you do not have one, a vice can do the job of squeezing the two sections together.

One 16-pin IDC connector should be attached to each end of the ribbon cable, on opposite sides and with the plastic tabs facing out from the middle, as shown in Fig.13.

Don't forget to feed the cable through the top of the connector first before looping it around to the blades below (the DAC project showed this the wrong way around – my mistake – although if you aren't putting a lot of stress on the cables it doesn't really matter).

Once you have made the cable, it's a good idea to plug it into both boards and use a DMM set to continuity mode to check that all the corresponding pins on the two PC boards are electrically connected. If you haven't crimped the cable with sufficient force, some of the blades may not pierce the insulation properly and those wires will read as open circuit.

If any lines are open circuit you will need to crimp the connectors harder, or make up a new cable.

Once you are sure that the cable is OK, leave it connected to both boards and reapply power. If you are using a bench supply, you should increase the current limit setting to 300mA, as the LCD backlight will draw additional current.

As soon as power is applied, the LCD backlight should turn on and some text should be visible. The current should be in the range 120-150mA. Initially, the display contrast will probably be too high but that's because we've erred on the side of caution to cater for any

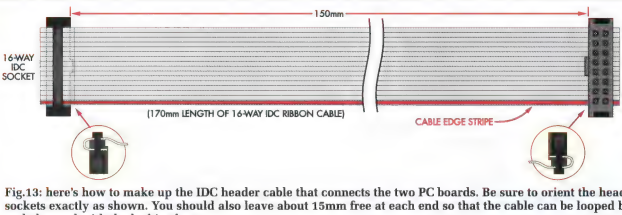



**Fig.13: here's how to make up the IDC header cable that connects the two PC boards. Be sure to orient the header sockets exactly as shown. You should also leave about 15mm free at each end so that the cable can be looped back and clamped with the locking bar.**

variations between the panels.

If you don't see anything on the display, check the cable continuity again, as well as the components and solder joints on the control board. It's also worth checking the components in the contrast control circuitry on the main board (ie, the circuitry associated with transistor Q5). If all the hardware seems OK, then you may have a faulty microcontroller or LCD module.

Once it is working, try pressing the "Up", "Down" and "Select" buttons and check that the display changes each time you do. Now turn the power off and then on again and try the "Left" and "Right" buttons. You should see a cursor appear on the display that you can move around.

Finally, press the "Left Mute" and "Right Mute" buttons and check that the display changes when you do. If your boards pass all these test, they are working properly.

## Adjustments & calibration

There are few tweaks that have to be made before the unit is installed in its case. However, be careful not to let the bottom of the control board short against the main board while you do this.

First, you should adjust the LCD contrast to its optimum setting. To do this, turn the unit off and then on again, then press the following sequence of buttons: Select, Up, Up, Left. The display will show the current brightness and contrast settings and you can now use the Up and Down buttons to adjust the contrast.

Once you have found a good setting, press Select, Up, Right. The display will now read "3.3V Cal.: 3.300V". When it does, carefully measure the output of the 3.3V regulator (REG2) – ie, black probe on pin 2 or the tab and the red probe on pin 3.

Once you have taken the reading, use the Left/Right buttons to move the cursor and the Up/Down buttons to change the digits on the display until it is as close as possible to the measured voltage.

Finally, press: Select, Down, Down, Left, Up. The display should read "Saved", indicating that the settings have been saved to the dsPIC33's flash memory.

Performing this calibration routine maximises the accuracy of the microcontroller's ADC readings, as they are measured relative to the 3.3V supply voltage. Once calibration is complete, remove the shorting jumper from the switch header.

## Preparing the case

The main PC board is designed to fit into a sealed polycarbonate enclosure with a transparent lid – either the Jaycar HB-6218 (171 × 121 × 55mm) or the Altronics H-0330 (186 × 146 × 75mm)

In each case, the transparent lid saves you the effort of having to cut a neat rectangular hole for the LCD to be visible. These polycarbonate enclosures are also quite sturdy.

The main board mounts on posts which are moulded into the bottom of the box. It is necessary to drill or cut holes for the outputs (three for the RCA sockets and one for the TOSLINK transmitter), a hole for the power switch and one for the DC connector.

If you are building the project from a kit, then it's likely that the case will be supplied pre-drilled. If not, then you will have to drill the holes yourself.

Fig.14 shows the drilling details for the Jaycar case and this can be photocopied and used as a drilling template. Alternatively, the equivalent diagram for the Altronics case can be downloaded from the SILICON CHIP website (note: Altronics will be supplying a kit with a pre-drilled case).

Once the template is in place, it is a good idea to temporarily place the main board inside the box and check that the sockets line up correctly with the indicated hole positions. When you are sure it is correct, remove the PC board and drill a small pilot hole in the centre of each RCA socket position. Also drill a small hole inside each corner of the TOSLINK connector outline (make sure that these do not go outside its outline).

By the way, there is a simple way to accurately drill holes in the plastic. At each location where you want to drill a hole, press the sharp point of a hobby knife there and rotate it several times, until you have made a small divot in the plastic. This will guide the drill bit and prevent if from slipping. Even if you are using a drill press, this simple technique will help to initially guide the bit.

Having drilled the pilot holes, remove the template and place the PC board back inside the box. Slide it up against the pilot holes and check that they are correctly aligned. You can do this by inserting a piece of wire into each hole and checking that it passes through the centre of the corresponding socket.

If any holes are misaligned, then now is the time to correct the situation.

When they are correctly lined up, use a stepped drill bit or a series of increasingly larger bits to enlarge the RCA socket holes. A tapered reamer

can then be used to get the size just right (about 10mm).

## Making the cut-out

The rectangular cut-out for the TOSLINK transmitter is made by first drilling a series of small holes around the inside perimeter, using the four corner holes you drilled earlier as a guide. It's then just a matter of knocking out the centre piece and filing the job to a smooth finish.

During this process, you can test fit the PC board to determine which sides need further filing. Continue this process until the connector is a neat fit.

Note that because of the thickness of the box, we've had to put the TOSLINK connector closer to the edge of the PC board than it is supposed to be. This means that the wider rear portion has to fit through the cut-out too. So, if it looks like it should fit but it won't go all the way in, it is probably the larger rear portion which is getting stuck.

When you are finished, the PC board should slide right up against the end of the case and the mounting holes on the board should line up with the posts. The TOSLINK transmitter face should sit flush (or nearly so) with the outside wall of the case.

## Power switch & socket

Before finally installing the main board, you also have to drill the holes for the power switch and DC socket. The recommended switch type is a 20mm round rocker type but you can use a different type if you like (eg, a sub-miniature toggle switch, as used in our second prototype).

The main thing to keep in mind is that the internal portion of the switch needs to clear the main PC board and its components. In the Jaycar case, that's done by mounting the switch on the side, between the PC board mounting holes.

The DC power socket is mounted on the side opposite to the power switch (see photos).

Once you have marked their positions, remove the PC board and drill two pilot holes. That done, enlarge the holes to the correct sizes using a tapered reamer – 20mm for the rocker switch and 7.5mm for the DC socket.

If you use the same switch we did, it will also be necessary to file a small notch in the top of the mounting hole. This is because the switch has a tab to stop it rotating. It doesn't take long to

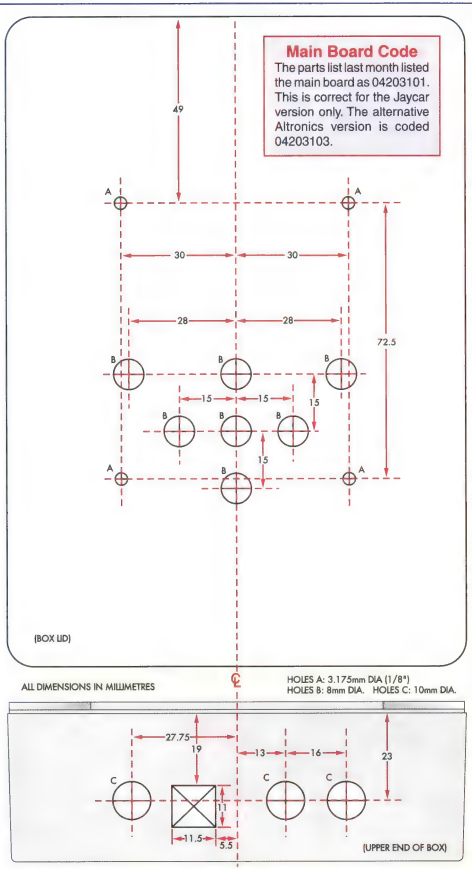



**Fig.14: this diagram shows the drilling details for the Jaycar case, while a similar diagram for the Altronics case can be downloaded as a PDF file from the SILICON CHIP website and printed out. The relevant diagram can be attached to the case and used as a drilling template.**

**This second prototype of the Digital Audio Signal Generator has been built into the Altronics case. Note that the pushbutton switch functions are screen printed on the control PC board (both versions).**

file away enough material and when you are finished, the switch should snap into the panel.

Alternatively, for the Altronics case, the switch and DC socket are mounted on the end panel, on either side of the output sockets. The locations of these holes are indicated on the drilling template (download it from the SILICON CHIP website).

## Installing the main board

Now you can slide the main PC board into place and secure it using four M3 x 6mm machine screws. If necessary, temporarily remove the power switch to do this, then reinstall it once the board is bolted down.

With the Jaycar case, two of the posts are pre-tapped with metal inserts but the other two are not tapped at all. It takes a large driver and a great deal of force to force an M3 machine screw into these untapped posts (as we did), so you may prefer to use two small self-tapping screws instead.

The Altronics case comes with four self-tapping screws to suit its untapped posts. We've provided extra holes in the PC board for the additional posts even though four are enough to hold the board rigidly in place.

## Drilling the lid

Fig.14 also shows the drilling details for the transparent lid (Jaycar version). There are 11 holes in all – four to mount the control board and seven for the pushbutton switches. The mounting holes (marked "A") are all 3mm in diameter while the switch holes ("B") are 8mm diameter.

As before, you should first attach the template and then use a sharp scriber or hobby knife to mark the centre of each hole. The template can then be removed and small pilot holes (say 1.5mm) drilled. It's then just a matter of enlarging the mounting holes to 3mm, while the switch holes should be carefully enlarged using a series of slightly larger drill bits to 8mm.

If you prefer, you can use M3 x 10mm countersunk screws (Altronics H3127A) to attach the control board to the lid. If so, you will need to countersink the mounting holes. Alternatively, you can use ordinary pan-head bolts.

## Installing the control board

To install the control board, first press a button cap down over the end of each switch shaft. Make sure that they are all firmly attached, although full engagement is easiest once the board is in place.

You should also attach the ribbon cable to the control board at this point, since it's almost impossible to do it once the board is bolted to the lid. Leave the other end unplugged for now.

Once that's done, it's just a matter of fitting the control board into place and securing it using four M3 x 10mm machine screws. Note that it may be necessary to slightly loosen the mounting spacers on the board to get them to line up with the mounting holes. They can then be re-tightened once the mounting screws are installed.

When the board is secured in place, press down firmly on each button cap to ensure it is fully engaged with its switch shaft. When that is done, they should protrude through the lid by 1mm or so.

## Front & top panel labels

If you buy a kit, it will probably come with the case screen printed. If not, you can download labels to suit your case from the SILICON CHIP website. The switch functions are screen-printed on the control PC board.

## Battery holder

The signal generator is designed to run from a plugpack or from four 1.5V cells, typically alkaline or NiMH. We used ultra-low self-discharge NiMH cells in our prototypes, so that they don't go flat if the device is not used for some time.

Note that if you elect to use alkaline cells, then the 1W charging resistor must not be installed on the main PC board (see panel).

Unfortunately, side-by-side 4 x AA-cell holders are not easy to obtain, although 4 x AAA-cell holders are

common. Of course, you can use AAA cells but battery life will be less than half that of AAs.

The best approach is to use a pair of side-by-side double AA-cell holders wired in series. These can be secured to the base of the box using two strips of double-sided tape each or they can be secured using countersink screws.

It's best to attach the leads before installing the holders. Attach a red wire to the positive terminal and a black wire to the negative terminal. If you are joining multiple holders in series, do that now.

Once everything is in place, connect the leads from the holders to the main PC board as shown in the wiring diagram. If you are using the 2-pin polarised headers, it's best to crimp and then lightly solder the wires to the connector pins before pushing them into the plastic block.

There is slightly more room for the battery holder in the Altronics box, so we used a 4 × AA holder with an integrated switch and lid. We did not install the lid since it would complicate access to the batteries should they require removal.

Note that because the switch is on the opposite side to the lid, it was necessary to use thicker foam-cored double-sided tape to attach it. The holder has integrated leads, so it is only necessary to attach them to the header connector before plugging it in.

## Wiring the DC socket

We have specified a 2.1mm DC socket since this is the most common type for plugpacks. However, a 2.5mm type is also available if that's what your plugpack's connector requires.

The polarity of a DC connector isn't always obvious, so it's best to check the plugpack itself using a DMM. To do this, connect the plugpack to the mains and then place the DMM's red probe into the hole on the connector and touch the black probe to the outer metal ring. If you get a positive voltage, then your plugpack is centre (tip) positive; otherwise it is centre negative.

For a centre-positive plugpack, connect the leads to the DC socket as shown on Fig.11, ie, red lead to the centre pin's solder tab and the black lead to the adjacent tab. Conversely, for a centre-negative plugpack, reverse the red and black wires.

Once you've soldered the leads to the DC socket, the free ends can be terminated in another 2-pin polarised header. Be sure to make the leads long enough to reach CON1.

**The Altronics version has the power switch and DC power socket mounted at one end of the case, along with the analog and digital output sockets.**

## Power switch

Almost any type of on/off switch can be used. The recommended switch is an SPST type but it doesn't matter if it is DPST or DPDT. Note that because the switch goes after the 7805 regulator on the main board, a small amount of power (at least 3mA) will be drawn from the plugpack even if the generator is switched off. This is so that the battery can trickle charge if you are not using the unit.

If your switch has spade terminals, crimp two 4.8mm female spade connectors onto appropriate lengths of wire and then attach the other ends to the remaining polarised header connector (it doesn't matter which way around they go). The spade connectors can then be fitted to the switch terminals and the connector plugged into the main board.

If the switch has solder tabs instead of spade terminals, just solder the leads directly to it.

## Finishing it

Now for the final steps. First, ensure that the power switch is off, then install the battery cells. That done, plug the ribbon cable into the main board and fasten down the lid of the case.

Because the switch header connector on the main board only just clears the underside of the control board, you may need to fold the ribbon cable slightly to the left, so that it doesn't get sandwiched between them. If it does, the lid won't sit properly and screwing it down could bend the board.

Also, check that there is no uninsulated copper where the leads exit the polarised header connectors. If there is, it could short to the underside of the control PC board. If there is some exposed wire, you will need to insulate it with electrical tape or heatshrink tubing.

Finally, it's a good idea to use the neoprene seal provided with the case, even though it is no longer water-tight thanks to the various holes. However, the seal will help keep the lid on tight.

That's it – construction is complete. Switch the unit on and make sure it works as expected. If not, remove the lid, unplug the ribbon cable from the main board, and check that the cells have been installed correctly and that the power switch is wired correctly.

That's all we have space for this month. It Pt.3, we will explain how to use the various modes and describe the various features in detail. SC

# Vintage Radio

By RODNEY CHAMPNESS, VK3UG

# The spark era - the beginning of radio

**The turn of the 20th century marked the birth of radio but the techniques used were very different from the techniques of today (or even 20 years later). It was the beginning of the "spark era", with crude transmitters that relied on spark gaps and equally crude receivers.**

AT THE TURN of the 20th century, radio or "wireless" (as it was known in those days) was very much in its infancy. Valves had not yet made their appearance and spark transmitters were the only transmitter format in existence.

Receivers started out with "solid state" detectors, coherers, galena crystal detectors and many other detectors of varying efficiency and ease (or was it difficulty?) of adjustment.

Wireless in the early 1900s was mostly used between ships and between ships and land stations. It was remarkable that in those early days, the receivers had no amplifiers at all and relied on the efficiency of the antenna, their tuned circuits and an earth to pick up signals. By using relatively high-powered spark transmitters, it was possible to receive signals hundreds and sometimes thousands of kilometres away.

If we were to connect a modern crystal set to a big antenna and an efficient earth like they did back in the early 1900s, we would obtain similar results. I know of a listener in Rockhampton who has listened to Radio Australia from Shepparton with a crystal set on 9MHz. The effective radiated power in that direction is of the order of five megawatts (5MW).

## Spark era equipment

It is not often that you see genuine or even replica wireless equipment from the spark era. However, when I attended the 25th anniversary of the founding of the Historical Radio Society of Australia (HRSA), I came upon a display of just such equipment by Ian Johnston. Many collectors have very early crystal sets using galena crystals but few have equipment that pre-dates the common use of this type of detector in receivers.

Spark era equipment is a rarity and this article cannot seriously attempt to present anything other than a brief overview of this early radio gear and

**A low-power spark gap transmitter from the early 1900s. The technology was crude by today's standards but signals from high-power transmitters could be received hundreds (and sometimes thousands) of kilometres away.**

its usage. Spark era equipment is very different to the equipment that came later and radio technology had been completely transformed by the 1920s!

Basically, the 20-30 year time frame from the turn of the century saw enormous technological advances in radio, some of it driven by the needs of World War 1. Technology drove advances back then just as it does today.

## Fundamental differences

During the spark era, diode and triode valves began appearing before World War 1. However, they were expensive, gave inconsistent results, were unreliable and had a short life. As a result, many believed they could not take those "new-fangled" valves seriously as by this time spark equipment was relatively reliable and was achieving consistent results.

There was also considerable resistance to the introduction of this "new" technology given that spark wireless technology was such a recent development and had become well established. However, history was to quickly prove them wrong – spark technology was destined to rule only from the time of Marconi's early experiments around 1894 to about the end of World War 1. After that, thermionic valve technology took over in just a few years. Even so, it's interesting to note that the Marconi School of Wireless in Melbourne still had a working marine spark transmitter (used for training purposes) as late as 1963.

Unlike spark transmitters, valve-type transmitters produce coherent signals, ie, signals which are on one frequency (the carrier wave). With modulation (eg, voice or music), the total amount of spectrum space occupied by a properly-adjusted transmitter is twice the highest audio frequency being transmitted.

For example, if the highest audio frequency is 10kHz, then the total frequency bandwidth is 20kHz.

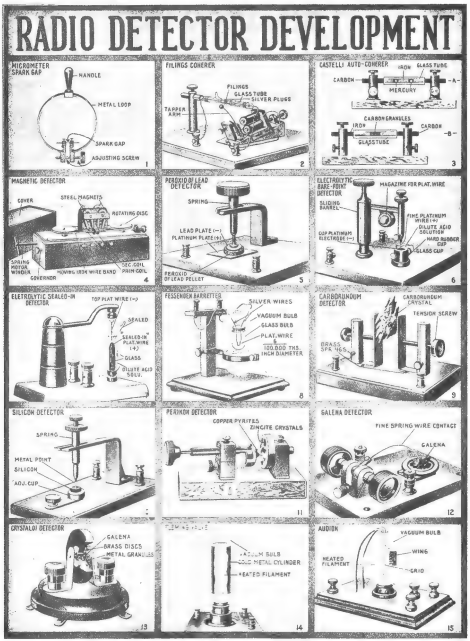
By contrast, spark transmitters

**This rather strange looking device is all that remains of an old quenched spark gap transmitter.**

## Kevin Poulter To Contribute

For some time now, Kevin Poulter has been contributing to this column with his "Set Of The Month" panel. Recently, he has also agreed to write some Vintage Radio columns and these will begin appearing under his name in future issues.

Kevin is an active committee member of the Historical Radio Society of Australia (HRSA), has a keen interest in vintage radios and will be writing on a number of interesting topics.




**Reproduced from *The Electrical Experimenter* (circa 1916), this page illustrates some 15 different devices that had been developed by the middle of WW1 to detect radio signals. Of these, the galena detector was widely used in crystal sets until germanium diodes became available.**

(particularly the early ones) were wide-band, with non-coherent transmissions on almost all frequencies. The spark transmitter at the Marconi School of Wireless could be heard up to 13MHz, although its assigned frequency was 500kHz. Is it any wonder that spark transmitters were eventually banned?

Initially, spark transmitters had an untuned antenna connected to one side of a spark gap and the other to earth. There was no tuning. However, as spark transmitter technology matured and tuning circuits were added, the amount of spectrum used did contract.

## Radio signal detectors

Reproduced with this article are a couple of pages of a publication called "The Electrical Experimenter" from around 1916. One page quite intrigued me and was titled "Radio Detector Development". It shows 15 different devices that can be used to detect radio signals.

Some of these we are familiar with and some we've probably never even heard of. One such device, called a "Micrometer Spark Gap", was used to detect and adjust the operation of a spark transmitter at close range.

The galena detector is much more widely known and was used in crystal sets until fixed-point contact germanium diodes became available. It was fiddly to adjust for a consistent, reliable signal which is why it was quickly superseded.

One that is really intriguing is the silicon detector. In its refined format today, it is the silicon signal diode such as a 1N4148. So a silicon diode was in use even 100 years ago!

Another detector that was commonly used in that era was the "coherer". The coherer usually had iron filings loosely filling a small space between two terminals. At rest, it exhibited quite a high resistance between the two terminals.

However, once a signal was detected, the resistance of the iron filings decreased dramatically as they "cohered" or aligned. The device then became useless as a detector when this occurred, so to get it back to its original state, a small device actuated by the change in resistance "tapped" the tube. This "de-cohered" the filings and reset the detector for the next Morse symbol dot or dash.

Naturally, this type of detector was only suitable for Morse code signals and was useless for radio signals.

The very early Fleming and Audion valves are also shown on the Radio Detector Development page. In fact, Edwin Armstrong developed the regenerative detector using the Audion and similar triodes. The regenerative detector held sway for many years as the preferred detector due to its extreme sensitivity compared to previous types of detectors.

A variety of other detectors including a magnetic detector, a peroxide of lead detector, an electrolytic bare-point detector, an electrolytic sealed-in detector, a Fessenden barretter, a carborundum detector and a perikon detector are also shown. During WWII, POWs even used rusty razor blades as radio signal detectors.

## Spark transmitters

A variety of spark equipment is shown in the pictures I took at the 25th Anniversary HRSA display. The examples shown are all very early low-power transmitters and are similar to those commonly shown in museums,

either as replicas or genuine original transmitters.

Most of these devices are the types used by early experimenters. As spark transmitters transmit on a very wide spread of frequencies, very little energy is transmitted on a single frequency (unlike valve transmitters). This reduced the available energy on the intended transmitting frequency, so the effectiveness of spark transmitters compared to valve transmitters was quite low.

This meant that the transmitting range of low-powered units would not have been great – possibly only a few kilometres at most.

In addition, the frequencies used in the medium-frequency range from around 300kHz to 1500kHz require large antenna/earth systems if reasonable efficiency is to be achieved. On small suburban blocks, the radiating efficiency was probably not more than 2-5%.

By contrast, the commercial transmitting sites that were used to contact ships had huge antennas and often had their own power station to provide power to the transmitter. Some of these stations required input powers of 100kW or more.

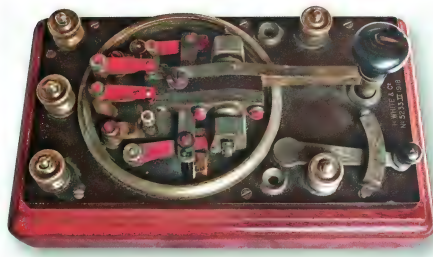
The voltages used on the transmitters were also extremely high, often up around 10,000V. Have you ever wondered why early Morse keys had a round bakelite disc underneath the knob on the key? In most cases, it was there to prevent the operator from being electrocuted should his fingers slip off the key's knob.

Of course, the voltage across the key was much less than 10,000V but it was high enough for a careless operator to receive a lethal shock. Occupational health and safety concerns were not very high on the list in those days.

## Tuning up

In 1900, Marconi took out a patent for "Tuned or Syntonic Telegraphy". This invention introduced tuned circuits to radio technology and meant that a wireless set (radio) could be tuned to a particular frequency, just as is done today.

By using tuned circuits and further improving the designs, the effective output power from spark transmitters was increased dramatically. In addition, the ability of the receivers to detect weak signals was greatly enhanced. This in turn meant greatly increased range, thereby making radio communications much more effective and economic.



**An early Morse key as used on land telegraph services (possibly the Overland Telegraph between Darwin and Adelaide).**

## Spark gap design

The original spark transmitters simply produced a continuous spark across the spark gap for as long as the Morse key was pressed. This produced a "raspy" sound which sounded much the same from the receiver. If the spark was fed with mains power, it would also have a 100Hz or 120Hz audio component (depending on the mains frequency) in the signal.

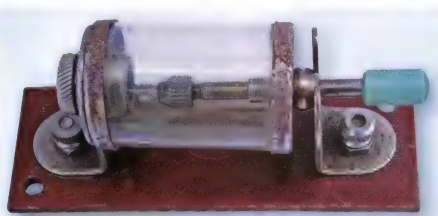
A few years after the development of the continuous-arc transmitter, the rotary spark gap transmitter was introduced. An example rotary spark gap is shown in the bottom righthand corner of the catalog page of the Manhattan Electrical Supply Company.

In this case, the mechanism consists of a number of studs with gaps between them. The system is somewhat like the distributor of a car – when the gap is small the spark jumps the gap and when it is larger, the spark is extinguished.

In operation, the distance between the points making the spark gap varies as the moving gap electrode is rotated by an electric motor. This means that the spark transmission will have a tone that relates directly to the number of times that the spark is made and extinguished each second.

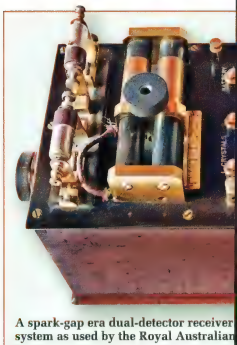
This tone can be quite musical – or as musical as a spark transmission can be! The tone would have been in the hundreds of hertz, which is easily detected by both our ears and the headphones in use at the time.

Interrupting the spark at quite a high rate and reducing the mark-space ratio (ie, the overall time that the spark oper-



**A galena crystal detector, as used in early crystal sets. They were fiddly to adjust to achieve a consistent, reliable signal.**

**Also reproduced from *The Electrical Experimenter*, this page shows some of the equipment that was available during the spark era. Note the rotary spark gap transmitter at bottom right.**



**A spark-gap era dual-detector receiver system as used by the Royal Australian Navy.**

ated) lowered the operating power. As a result, rotary spark transmitters were more effective and more efficient than earlier spark transmitters.

## Spark gap erosion

There was considerable erosion of the gap points in both the original continuous and the later rotary spark transmitters. This problem was overcome with the development of the quenched spark gap transmitter.

In this device, the rotary gap was enclosed in a sealed chamber. After a short period of use from new, the oxygen in this sealed container was all used up and little erosion of the points then took place.

Other than that, the quenched spark transmitter was similar in concept to the rotary gap spark transmitter. There may have been other more sophisti-

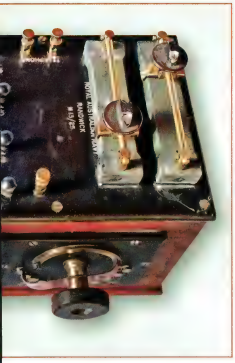
## Buffer Capacitors In Vibrator Power Supplies

In a column several months ago, I suggested that polyester capacitors could be used to replace the original buffer capacitors in vibrator-type power supplies. However, since then, a reader has pointed out that due to the severe pulse nature of the waveform, the foil inside such capacitors would separate into bits and pieces. As a result, the capacitor would become ineffective, with subsequent damage to the supply.

The solution is to use polypropylene capacitors designed for pulse circuits, such as those around the horizontal output stages of CRT TV receivers. These capacitors are readily available from WES Components of Ashfield, NSW. They have quite a large inventory of parts, many of which can be used in vintage radios. They even have a selection of valves, although most of these are for audio amplifiers.

By the way, when readers ask for information, I will assist if I can but please keep the queries short and to the point. I simply do not have the time to engage in lengthy research or write lengthy, detailed answers (unless I can turn the query into an article).

When it comes to identifying an old radio, I need to have more information than just a hazy photograph of the unit. If you can, it helps if there are details on the valve line-up, any identifying numbers on the chassis and the manufacturer. Clear photographs of the chassis (both top and bottom) are also handy.



cated spark transmitting techniques developed later on but I'm not aware of any.

## Finding out more

Although our knowledge of the valve and transistor eras is quite extensive, the spark era is almost unknown and I for one would like to know more.

Unfortunately, old spark era equipment is almost impossible to obtain but there are bits and pieces around as can be seen in the photographs included with this article.

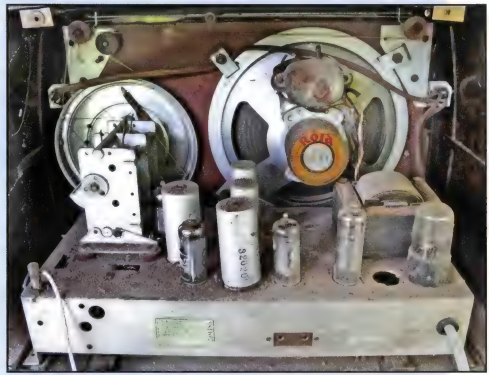
Old wireless books up to around 1925 will have information on spark transmitters and these should be grabbed before they are destroyed. The information in these will often be limited though, as a lot of the work was done by enthusiasts and experimenters in those days and is undocumented.

Ian Johnston is one of the few people around today who know much about spark era equipment and he was kind enough to allow me to view and photograph much of his equipment, as well as providing sources of information.

If you would like to hear what a spark transmitter sounded like, try this website: **www.physics.otago.ac.nz/ursi/belrose/sparkx2.AIFF**

Finally, further information on the spark era is available on **www.rod.beavon.clara.net/spark.htm**. Peter Jensen's book "In Marconi's Footsteps" is worth looking at too if you can find a copy. SC

## Photo Gallery: Philips Radioplayer 124



MANUFACTURED around 1950, the Philips Radioplayer 124 was a 5-valve mantel set in a Bakelite cabinet. It employed a fairly standard superhet circuit with 455kHz IF stages and covered both the broadcast band from 530-1620kHz and the shortwave bands from 5.9-18.4MHz. The valve line-up was as follows: 6AN7 frequency converter, 6N8 IF amplifier, 6N8 detector plus AGC & first audio stage, 6M5 audio output stage and a 6X5GT rectifier. In this set, the speaker transformer laminations are connected to the HT (B+) line but the unit was normally rendered safe by the transformer core being pitch-encapsulated inside the housing. The above photos show an unrestored unit.

# ASK SILICON CHIP

**Got a technical problem? Can't understand a piece of jargon or some technical principle? Drop us a line and we'll answer your question. Write to: Ask Silicon Chip, PO Box 139, Collaroy Beach, NSW 2097 or send an email to silicon@siliconchip.com.au**

## Laptop needs more power

Way back in 2003 you published a DC-DC Converter For Cars. I built one and I now have a newer laptop PC and it draws 3A. I can charge it back up again but it will not power it for use. It requires 19V @ 2.85A.

How can I modify it to do the job? (L. S, Ultimo, NSW).

● The 1000µF 25V and 470µF 50V low-ESR capacitors will need to be paralleled with duplicate capacitors to double the ripple rating. In addition, Mosfet Q1 and diodes D1 & D2 will require more heatsinking, while inductor L1 will need to be increased in size by stacking two of the 17-742-22 cores together and winding on about 28 turns of wire around both cores.

The windings are made up of 1.25mm enamelled copper wire or two strands of the 1mm wire twisted together. The 0.1Ω 5W resistor would need to be shunted with another resistor of the same value to double the peak current for L1. The fuse will need to be 7.5A and the power switch rated at 10A.

On the PC board, the current carrying tracks will need to be beefed up by running a layer of solder over them or by soldering several layers of 0.7mm tinned copper wire over the tracks.

## Flasher unit for vintage cars

I wish to build three turn signal flashers for vintage cars using 6V batteries (modern 12V flasher units cannot be used). Only mechanical 6V flashers are presently available and they are not satisfactory. Can you help? (R. G., Kayena, Tas).

● A flasher unit for cars was published in Circuit Notebook for August 1989. It can run on 6V, providing a 6V relay is used. Unfortunately, you cannot access this old circuit on our website but we can supply a photostat copy for $12.00, including postage.

## Query about amplifier distortion

The THD graphs you publish for amplifiers show the distortion as lower for 8-ohm than for 4-ohm loads. Will distortion continue to reduce for increases in load?

Related to the above question, how could I feed one amplifier (the excellent SC480) with the stereo output from a lesser quality 5-channel amplifier? It does not have preamp outputs.

Would a 1kΩ resistor in series with the input and 1kΩ in parallel to earth provide a suitable level of input and protect the amplifier? How could one calculate the required values? (R. R., Auckland, NZ).

● The distortion in all amplifiers increases as the load impedance is reduced. The fact that higher currents are being supplied by the amplifier means that the output non-linearities are worse.

As far as feeding a signal to the SC480 is concerned, using 1kΩ resistors may be an excessive load for the preamplifier. You are better off using a 10kΩ pot to set the levels.

## How to trigger a model railway timer

We at the Clare Valley Model Engineers run 1/8th-scale trains on a 7¼-inch track and have used PICAXE08 micros as timers to sense trains as they approach the points, etc. These have worked very well. However, our sister club at the Roseworthy Campus of the Adelaide University have tried the same trick using the Special Function Timer (SILICON CHIP, October 2008) but have run into problems with the sensing speed.

We and they have been using a brass bolt in the steel track as a wheel detector and as the average speed of a train is 10km/h, the pulse is about 1/500th

## High-Current Speed Controller Needs Setting Up

I assembled the High-Current Motor Speed Controller kit and all appears OK except that every 12 seconds, the display indicates 'LO' and the buzzer sounds. This occurs running or stationary and the supply voltage is steady.

The kit notes don't mention an 'LO' indication. It also seems that the Mosfets are not turning on fully when the motor is loaded. If the motor is running at, say, 90% and I stall the motor, the display continues to read 90% and there is no increase in output from the controller.

I have checked everything I can on the board and have decided to change the microcontroller. Am I on the right track? (J. B., via email).

● The 'LO' indicator is there as a warning that the battery voltage (or the input voltage to the Speed Controller) is lower than the threshold (ie, it acts as a low-battery indicator). The threshold for this alarm (ie, the level in volts below which the alarm will sound) can be changed by going to the Alarm menu. This was explained on page 39 of the March 2008 issue.

The 90% indicator means that the motor is running at 90% of full speed (as measured by the back-EMF from the motor). Therefore, the fact that the percentage stays steady when you stall the motor shows that there IS speed regulation. The speed controller will try to maintain the speed (as measured by the back-EMF) constant according to the level set by the potentiometer.

Of course, if you stall the motor too much, the controller may not be able to regulate the speed and you may cause a fault condition.

In other words, from the symptoms you describe, it seems that the controller is working normally.

of a second. We have estimated the reaction time for the Special Function Timer to be about a tenth of a second as even a quick pulse by hand will not get a response.

Is the problem the speed of the program or would there be some other problem? Is there a way that we can capture the trigger signal pulse and hold it high long enough for the timer to register it? (D. L., Clare, SA).

● The timer includes a debounce period to prevent false triggering and so short pulses will not trigger it.

The way to extend the signal from the train detector depends on what signal is obtained. If it is a positive voltage for train detection and 0V when not detecting the train, then the pulse can be extended by increasing the 10nF capacitor at the collector of Q1 to 100nF and the 10kΩ resistor at Q1's collector to 100kΩ.

There is no easy way to extend the pulse seen by the PIC if the signal goes to 0V for train detection.

## PICAXE for model railway traffic control

I would like to use a PICAXE micro in conjunction with model railway points (turnout) switching. The points solenoids are operated by 16-17V AC via a normally-open (NO) pushbutton switch. I would like this momentary signal to trigger one of a pair of input pins, which would then make one of a pair of output pins go high and the other of the pair go low.

Similarly, the other of the input pins would (when operated) toggle the two output pins. The output pins would light a LED on a diagram to indicate which leg the points are being switched to. Can I use a diode (1N4148) and a 4.7V zener diode to "treat" the AC input signal?

I presume I would have to use interrupts in the program so what chip (20M?) should I use, remembering each point needs two inputs and two outputs, running one LED at a time? There will be 50+ points to operate in this manner so cost is a big factor.

Can memory be programmed in so that at switch-on prior to a "running session", the "high" output pins from the previous session will come on? Please indicate which chip would be the best for the above. (R. B., via email).

● The 16-17V AC signal can be monitored using a single resistor to limit current into the PIC input. PIC inputs include input clamping with diodes to the 0V and 5V supply. The resistor can be around 10kΩ. A 100nF capacitor at each PIC input would reduce noise.

The PIC can be programmed to remember past events so it returns to the last state on power up.

The PIC type really depends on how many pins you need. It seems that with 50+ points and two inputs per point you would require some sort of multiplexing of the points inputs instead of using a PIC with 100+ inputs plus outputs. So PIC choice really needs to be considered after the input multiplexing circuitry is sorted out.

## Antennas for digital TV

I read with interest the "Dead Simple Masthead Amplifier" article in the November 2009 issue. I can vaguely recall that many years ago and probably in an issue of the former *Electronics Australia* magazine there was a project to build a TV antenna. I can't recall the exact details of this project (including which year or issue it was in). However, with the introduction of digital TV and the phased switch-off of the analog signal over the next few years, I was wondering whether SILICON CHIP was considering the development of an update to that "original" TV antenna project, as I understand it now owns the rights to all previous EA projects.

Would it be possible to come up with an antenna that was of the same (or higher) quality as the commercially-available antennas and at least of competitive but ideally cheaper cost? (P. M., Karabar, NSW).

● We have described two UHF 4-bay bow-tie antennas, in January 1988 and July 1994 and we described a UHF corner reflector antenna in June 1991. All of these should perform well for digital TV.

However, building your own antenna may not be a worthwhile proposition these days since the cost of aluminium is quite high and com-

## Huge Bass Wanted From Class-A Amplifier

I have a question about the bass of the SILICON CHIP 20W Class-A Amplifier. Krell is well-known for their huge bass and I was wondering if I could get that with the sound quality of the 20W Class-A Amplifier (unless you're planning to upgrade to a 200W or so class-A design). I'd like to know if I could use much larger transformers. My amplifier has dual power supplies (transformers also) in a separate enclosure.

I'm not sure if it would be possible to have something like two 2500VA custom-made transformers but with 16+16V windings to suit the power supplies and much larger and/or more capacitors. I'm looking to equal the VA rating of the Krell KSA-300S's single 5000VA rating.

Since only the amperage can be increased, would this not increase the bass? Krell must be doing something special to get that bass and I'm prepared to spend the extra cost on a new large enclosure for the power supplies.

I don't know much about capacitors and would appreciate any advice and specifications of parts on this if it's possible. (N. D., via email).

● The bass response of the Class A amplifier is absolutely flat to below 5Hz and is only -3dB down at 1.5Hz (which is almost DC). So it is simply not possible to improve, enhance or otherwise boost the bass unless you employ tone controls in your preamplifier (assuming that you have tone controls). We would not recommend you do this as they will inevitably compromise the extremely low distortion of the amplifier.

As a general rule, if an amplifier is notable for "huge bass" it suggests that something is not quite right – perhaps the bass response is being boosted when it should be "flat" for a true high fidelity amplifier. "Huge bass" might be desirable if you want to turn your car into a sonic weapon of mass destruction but it has no part in high-quality sound reproduction.

We have no plans to produce a bigger class A amplifier – it would simply be too expensive for most enthusiasts to contemplate. If you want a higher power amplifier with really good performance, have a look at the Ultra-LD series.

## Simple Approach For Solar Hot Water Boosting

I have been a subscriber to your excellent publication for the past five or so years and find the articles on the latest technology fascinating and informative, the project and Circuit Notebook sections of immense interest, the editorials succinct and relevant and the various advertisers well targeted for your subscriber base.

I have a couple of queries with regard to project design and availability, and whether these may have been covered previously by SILICON CHIP.

First, we have a solar hot water system, with the electric booster switchable via a switch in the bathroom, connected to off-peak (normally available from 11.30 PM until 5.00 PM or so). Unfortunately we work during the day, so the only way we know whether it has been a totally overcast day (we live on the Atherton Tablelands, where it can be sunny in one spot but totally overcast 30km away) is from the lukewarm water issuing from the hot water tap. Normally this revelation occurs after the off-peak has shut down.

Is there any way of automatically monitoring the temperature of the water in the system at a predetermined time (say 4.00 PM) and if it is below a certain temperature, maybe 40°C, then switch the booster on?

Second, I have a hand-held GPS which I use for hiking and bush-walking, as well as when out in my boat. Is there any way to connect the video of a hand-held unit onto a separate screen for better visibility whilst the unit is in the boat? (S. A., East Barron, Qld).

● Your problem with solar hot water is a common one but it has not been directly addressed in any SILICON CHIP designs.

Two Circuit Notebook items, published in December 2005 and March 2009, are relevant since they are directed to measuring the temperature of the tank but they do not address the issue of a timer and a comparator/relay circuit to do the switch-over. In that respect, the December 2005 circuit is perhaps more useful since it does include a comparator which could be adapted to drive a suitable 240VAC-rated relay.

However, a simpler approach may be possible. If the booster element is controlled by an internal thermostat (normally the case; otherwise the tank could boil), perhaps all you need is a timer to automatically connect the booster every day at 4PM (or whenever). That way, if the tank is already hot, the booster element will not cut in, even it is switched on and you should always have hot water.

Unfortunately the picture displayed on your GPS is not compatible with the video standards of typical monitor screens.

mercial 4-bay antennas cut for the digital channels are quite reasonably priced (by comparison with the cost of aluminium).

By the way, while we are keen on the 4-bay bow-tie design because it is not such an attractive perch for birds, its strong point is its rejection of reflections (ghosts) from the rear (ie, its front:back ratio is high). Long Yagis are much better at rejecting reflections from the side (ie, narrower forward lobe). However, reflections are not so critical with digital reception.

## 6-digit GPS clock query

In the GPS Clock project (May & June 2009) you have the output of the micro driving an NPN transistor which in turn drives a PNP transistor and then the 7-segment display. Is it not possible for the software to pull the respective micro pin low instead of high to turn on the displays and hence you could do away with the NPN transistor? I ask this simply to further improve my knowledge. (M. D., Perth, WA).

● You are quite correct in proposing that the NPN segment driver transistors could be omitted simply by arranging for the PIC to pull down the I/O pins to turn on the various segments, via the PNP transistors. However this does have one shortcoming: when power is first applied to the PIC, it clears all its I/O port registers and this would turn on all the display segments until the firmware was able to set all the appropriate I/O pins high.

That's why we elected to add the NPN transistors, so that the display segments would all be "off" by default.

## WAV file timing problem

I built an SD Card Player/Recorder kit (SILICON CHIP, August 2009) to try out in a series of projects which need audio. Electrically it seems OK but the WAV files are playing 6.5% slow.

The first project that I need to use this on is for sound on an Edison cylinder player in a museum. The Edison is in working order but the stylus is removed. Only one channel of sound is used, the other having cue signals which are detected by a PIC to operate the motor and solenoids and to select and start the audio (which comes out through the horn via a cellphone speaker).

We have several dozen tracks edited to 124 seconds with cues accurately placed to make the simulation as realistic as possible. Because the WAV files are playing slow (about 132s), all that's gone out the window unfortunately.

I've checked the audio player's crystal and that's measuring 10.000MHz. The WAV files are 44.1kHz 16-bit signed and they play to the proper time on any PC or MP3 player. Do you have any suggestions on what might be the problem? (J. Q., via email).

● The WAV files are playing at a frequency that is approximately correct, derived from the crystal. It is not exact – different dividers with different errors are used (within what the PIC hardware allows) to account for different sampling rates for different WAV files.

As you will appreciate, it would be difficult, with a single crystal and the hardware available on the PIC, to have an exact sampling frequency for every possible frequency allowed in a WAV file, hence the approximation and the errors you are observing.

We don't know exactly what cue-

ing system you are using but it may be possible to change the cues to account for the slowness you observe. Alternatively, resampling your files at a sampling rate that evenly divides 1,250,000 would minimise the errors.

## Interfacing a microcontroller

I am about to interface a Microchip PIC device running at 5V to 433MHz radio transmitter and receiver modules designed to run at 3.3V. Is there a straightforward way using resistors and/or diodes to match up the incoming and outgoing data levels or will I need to look into the various level translator ICs available from companies like Maxim etc? (J. P., via email).

● Many 433MHz transmitter/receivers will run on 5V as well as 3.3V. Check the data sheet carefully for the absolute maximum supply rating. If they can run on 5V, this will be shown as an absolute maximum supply of 5.5V, for example. If absolute maximum supply is less than 5V then you will need to run on 3.3V and use level translation.

Converting from a 0-5V signal to a 3.3V signal is easily done with a resistive divider from the PIC output to the transmitter input. Use a 2.7kΩ resistor from the PIC output to the transmitter and a 4.7kΩ resistor from the transmitter input to ground.

Many 5V microcontrollers can handle 3.3V signalling directly (check the datasheet). However, if level translation is necessary, you can use a general-purpose NPN transistor such as a BC547. A 10kΩ resistor from the receiver output drives the transistor base. Its emitter is connected to ground and the collector is tied to the 5V supply via a 2.2kΩ resistor. The collector signal (which will be inverted compared to the receiver signal) is applied to the PIC input. The signal inversion is not a problem as this can be catered for in the PIC software.

In both cases, the maximum frequency will be limited to 50-100kHz. To transmit and receive data faster, it will be necessary to use a level shifter IC.

## Notes & Errata

**Digital Capacitor Leakage Meter, December 2009:** it has been found that this unit reads higher than it should with typical electrolytic capacitors. Similarly, large metal film capacitors do not correctly read zero leakage. This is due to ripple voltage from the switchmode power supply being coupled across the capacitor being tested.

The cure is to connect a 100µF 16V low leakage (LL) electrolytic capacitor between the negative test terminal and ground. The positive lead of the capacitor is connected to the negative test terminal. It can be installed on the underside of the PC board.

This completely fixes the problem at the 10V and 16V settings and greatly improves leakage readings at higher voltage settings.

## Query on high-current speed controller

I was very interested in your 12-24V High-Current Motor Speed Controller as featured in the March & April 2008 issues. I was particularly interested in your design because my final year project for my degree, which I completed over 20 years ago, was the speed control of a DC motor.

I do have a technical query about the design. I was concerned that the 56Ω resistor connected to the base of transistor Q3 might be too small in value. By my reckoning, when PIC port pin RB0 goes high, as it does when the motor speed pot is turned to 0% to stop the motor, then the circuit is attempting to pull over 70mA out of RB0, thereby risking damaging the output.

The 16F88 data sheet says that the maximum current which can be sunk or sourced by any port pin is 25mA. I wondered what your response would be to my suggestion of increasing the size of this resistor by a factor of 10 to 560Ω. Obviously the other resistor connected to the base of Q3 would also need to be increased by a factor of 10, to 10kΩ in order to ensure that Q3 switches off properly when RB0 goes low. Would this modification have any undesirable effects which would need to be avoided?

I calculate that Q3 requires less than 2mA of base current to fully saturate. Increasing the value of the resistor in question to 560Ω would provide over 7mA of base current whilst meeting the RB0 output specification. (C. H., via email).

● Your reasoning is sound. The way that the RB0 pin is driven is through PWM and it is also frequently Tri-stated (becoming an input) to sense the back-EMF from the motor. When the RB0 pin is high, the Mosfets turn off and when low, they turn on.

Measurements on our prototype

*. . . continued on page 103*

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## Ask SILICON CHIP – *continued from page 101*

show that the voltage across the 56Ω resistor never exceeds about 1.5V which is within the safe operating area for IC1. We suspect that the PIC is limiting the current through the resistor and no damage is occurring to the pin.

The modification that you suggest could be tried – however you should make sure that the transistor turns on and off quickly to really switch the Mosfets hard enough to prevent them overheating. We found that a resistor value of 56Ω worked OK but higher values may not work as well.

## Windows-based electrocardiogram

I have an *Electronics Australia* magazine dated July 1995 showing construction details for a PC-Driven Electrocardiogram with enclosed listings for a GWbasic program to run the ECG. I would appreciate it if you could let me know if it is possible to get a later program to run on a PC with the Windows XP operating system. (J. D., via email).

● We do not have Windows software for that ECG project. However, SILICON CHIP published a USB ECG project which links to a PC or laptop in the September 2005 issue. It does use Windows software.

## Simple voltage switch for a solar panel

I am looking for a device to switch a load depending on the output voltage of a 24V solar array. The open-circuit solar array may go as high as 34V and is zero when in shade or at night.

The article entitled "Simple Voltage Switch for Cars" in the December 2008 issue looks promising. Could you advise what changes I would need to make in order to operate this project from a 24V system? A 24V battery is connected and could be used to supply the driving voltage. (J. G., via email).

● For 24V operation, the two 100µF 16V capacitors and the 10µF 16V capacitor at the input of REG1 should be changed to a 50V rating. ZD1 should be a 32V type, Relay 1 should be a 24V type rather than 12V and the 1.8kΩ resistor for LED should be changed to 3.3kΩ 0.5W. SC

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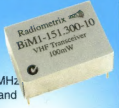


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